SLOW the FLOW COLORADO

Irrigation Inspection Program

2009 Annual Report

Town of Erie

Prepared by the

CENTER FOR ReSource CONSERVATION

Conservation Starts Here

January 2009

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About the Center for ReSource Conservation

Founded in 1976, the Center for ReSource Conservation (CRC) is a Boulder-based 501(c)3 non-profit organization which empowers our community to conserve natural resources. Each year, the CRC empowers more than 30,000 individuals to live a more sustainable life through educational programs and services designed to help members of our community conserve water and energy and minimize waste.

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I. Executive Summary

The Slow the Flow Colorado Irrigation Inspection Program is operated by the Center for ReSource Conservation (CRC) to help people water more efficiently with their sprinkler systems. The inspections provide a unique combination of customized, pragmatic advice and one-on-one education for a homeowner or property manager. Inspections are available free to customers of participating water providers, and customers sign up voluntarily through the CRC. In 2009, the CRC performed 136 inspections on residential properties and 4 inspections on large properties, which included homeowners associations and commercial properties in the Town of Erie service area. At the end of the 2009 Slow the Flow season there were 215 Erie residents on the waitlist for to receive an audit.

For the purposes of this report, data from residential and large properties were combined due to lack of sufficient data needed to analyze large properties. A sample large property report is attached as Appendix D.

The annual report presents the data collected during these inspections. The data includes technical sprinkler efficiency data, participant information, survey results of participants about water conservation features and watering practices. This report strives to present the data in a clear, understandable format, provide appropriate context, and summarize important trends. The report will make occasional recommendations, but strives to present the data and trends and allow the reader to decide what actions to take next.

The Steps of an Irrigation Inspection

In an inspection, a trained CRC auditor visits the property and performs the following steps:

1. Gather Participant Data
2. Visual Inspection
3. Catch Cup Tests
4. Pressure Readings
5. Soil and Root Depth Tests
6. Landscape Measurements
7. Determine Watering Schedule
8. Share Test Results and Recommendations With Participant

Property Information

For residential properties, CRC auditors looked at the irrigable landscape size, number of residents, age of the property and sprinkler system, and how long people had lived in their homes. In Erie residential properties had a median irrigable landscape size of 4,700 square feet, and an average of 2.93 residents. The median house was built in 2002, and the median sprinkler system was installed in 2003. Residents had lived in their houses for a median of 3 years.

CRC auditors surveyed residents and property managers about water conservation features present on their property. The most common outdoor features were some xeric areas and drip systems, with 71% and 80% of properties having them.

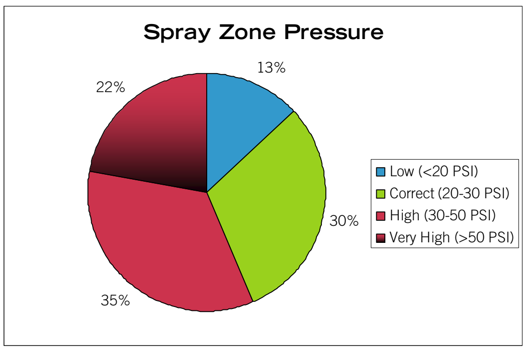
Clay soils were the most common soil type observed. In Erie, 81% of properties had clay soil, while 11% had soil mostly with a makeup of sand. In order to avoid runoff and water waste from irrigating clay soils inappropriately, people should use a watering technique called 'cycle and soak' irrigation. In 2009 27% of participants were using this technique before their inspection. The CRC recommends that cities should continue to educate their residents about cycle and soak irrigation for clay soils.

Sprinkler System Information

During the catch cup test portion of each inspection, auditors calculate a measure of sprinkler system efficiency called distribution uniformity (DU). DU is a measure of how evenly a system waters, and directly affects how much water people apply to the lawn. It is measured in percentage, and the CRC considers a DU value of over 70% as acceptable. Only 16% of zones tested in Erie had acceptable DU values. DU values were significantly higher for rotor zones than for spray zones.

Sprinkler Heads 101

There are two basic types of sprinkler heads: **spray heads** and **rotor heads**. Spray heads water in a fixed pattern when the system is turned on. Rotor heads water in a rotating pattern as they spray, usually covering a larger area.



Rotor zones also had significantly fewer and less severe pressure problems than spray zones did. Over 35% of all spray zones had high pressure, and 22% had extremely high pressure. Only 2% of rotor zones had problems with high pressure. This could be due to the fact that the designed pressure for rotor heads is significantly higher than that of spray heads. High pressure causes a significant amount of water loss to evaporation and wind.

The most common problems found on properties were

- Overspray
- Low heads
- Inefficient watering schedule
- Poor head spacing

CRC auditors found overspray on 94% of all properties and low or tilted heads on 90%. Overspray is both a waste of water and a significant source of nonpoint source pollution.

High pressure and overspray onto a sidewalk

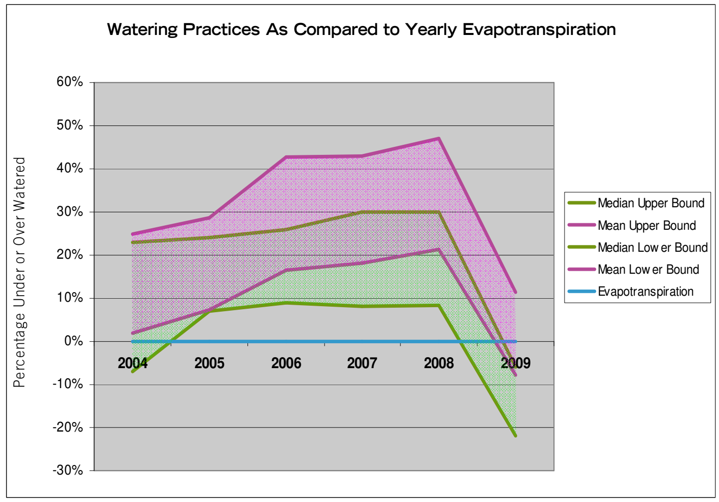
Based on the results of the inspection, CRC auditors recommended a watering schedule to program participants. In the annual report, the CRC compares the recommended schedule with the schedule in place before the inspection. Most residential participants were watering their spray zones for roughly the same amount of time as the CRC recommends and their rotor zones for somewhat less time than the CRC recommends.

Different Watering Times for Spray and Rotor Zones

Spray heads and rotor heads emit water at different rates, and need to be programmed to water for different amounts of time; The CRC found that on average spray zones should be watered for 60% of the length of time that rotor zones do.

Participant Watering Practices

The CRC analyzed water usage, landscape sizes and weather data to determine participants' watering practices as compared to evapotranspiration (ET), the amount of water that plants lose to evaporation and transpiration each year. This year's Erie participants overwatered by a median of 25.5% during the summer of 2008.

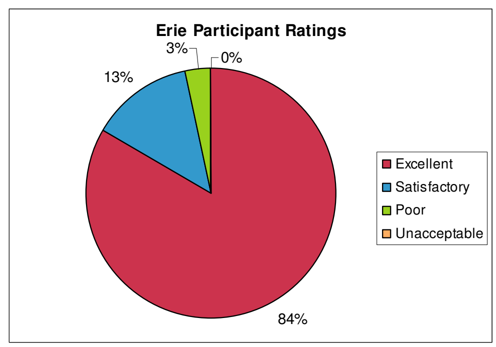


Efficient Watering

The CRC compared watering practices to sprinkler system efficiency to measure how many zones were efficiently watered. Zones that had acceptable DU values and pressure levels were considered efficient. Less than 4% of zones in Erie were efficient and watered appropriately. More rotor zones were efficient and watered appropriately than spray zones.

Evaluations and Program Effectiveness

In 2009, program participant evaluations were very positive. The CRC received 31 responses from Erie participants, a 22% response rate. 97% of Town of Erie's participants rated the program as either excellent or satisfactory; 84% rated the program excellent and 13% rated it satisfactory.



The CRC performed a study in 2007 to evaluate the effectiveness of Slow the Flow Colorado. The study looked at the watering practices of residential participants audited during 2004 and 2005 before an audit and after an audit. The study found a statistically significant reduction in water use relative to ET for participants that were overwatering prior to an audit. Participants that were watering appropriately or underwatering prior to an audit did not reduce water use. The CRC would like to do a follow-up study to see if any new trends surrounding the impacts of this program have since emerged. The Executive Summary of the study is included as an appendix to this report.

Partner Utilities

Aurora Water
Castle Pines Metropolitan District
Centennial Water & Sanitation District
City of Boulder
City of Golden
City of Lafayette
City of Longmont
Cit of Louisville
City of Northglenn
City of Thornton
City of Westminster
Left Hand Water District
Town of Castle Rock
Town of Erie
Town of Superior

II. Background

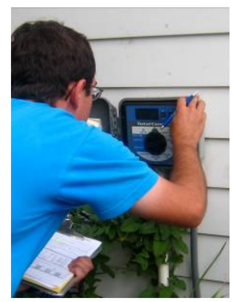
Slow the Flow Colorado is an irrigation inspection program run by the Center for ReSource Conservation (CRC) to educate people about how to water more efficiently with their sprinkler systems. In an inspection, a trained auditor comes to a residential or large property, does a thorough inspection of the sprinkler system, and spends time educating the homeowner or property manager about what to fix on the sprinkler system and how to water more efficiently.

Slow the Flow Colorado is modeled on a program developed by the Utah State University Cooperative Extension called Slow the Flow Save H20. In 2003, the City of Boulder ran Slow the Flow Colorado as a pilot program. In 2004, the CRC started operating the program, performing 428 residential and 51 large property inspections for five water providers. The program has grown steadily since then; in 2009, the CRC performed 1420 residential and 85 large property inspections for 15 water providers.

The steps of an irrigation inspection

1. Gather participant data

At the beginning of the inspection, the auditor meets with the participant. The goal of this time is to gather all relevant information and often the auditor will ask what the participant's goals for the inspection are and what they hope to get out of it. Auditors also survey the participant about indoor and outdoor water conservation features and record property information, such as the current watering schedule.



Recording the current watering schedule

2. Visual Inspection

The auditor visually inspects the sprinkler zones while they operate. Auditors inspect all zones on residential properties and up to 50 zones on large properties in order to reduce the waitlist and allow the program to reach more participants.

The auditor requests that the participants accompany them during the inspection. The auditor identifies the head type (rotor, spray or drip) on each zone, notes damaged or malfunctioning heads, and identifies and troubleshoots other system problems. The participant is strongly encouraged to participate and take notes during the visual inspection.

Auditor visually inspecting system

3. Catch Cup Tests

A catch cup test measures the distribution uniformity (DU) and precipitation rate of each zone. Distribution uniformity is a measure of how evenly the system waters, which affects the amount of water required to keep the landscape healthy. Slow the Flow auditors use the lower quartile method to calculate DU. Precipitation rate is the amount of water emitted by the system in a given amount of time, and helps determine an appropriate watering schedule for that zone. Auditors generally test two areas on residential properties and between four and ten areas on large properties. Due to the different characteristics of rotors and sprays, auditors try to conduct at least one catch cup test on a rotor zone area, and at least one on a spray zone area.

Catch cups on a side strip

To perform a catch cup test, the auditor lays out a series of standardized and graduated cups in a grid pattern across the area to be tested. The auditor then turns on the system for a given period of time (five or ten minutes depending on the head type), turns it off, and measures the amount of water in each cup. From these measurements, the auditor calculates the distribution uniformity and precipitation rate for the area.

4. Pressure Readings

The auditor takes dynamic pressure readings for each zone on which they perform a catch cup test. On spray zones, the auditor removes the nozzle and attaches a pressure-T, then turns the zone on. On rotor zones, the auditor inserts a pitot tube attached to a pressure gauge into the running stream of water spraying from a head. The auditor will also use pressure measurements as a means of troubleshooting suspected problems, such as leaks. For a more detailed discussion of pressure, see the system pressure section below.

Pressure-T attached to spray head

5. Soil and Root Depth Tests

On each zone tested, the auditor collects a soil core sample using a soil probe to determine the soil type and root depth. Soil types are evaluated as clay, loam, sand, or sandy clay, and are used to help determine a watering schedule. Root depths are measured in inches. Often, the hard clay soils of the Front Range prevent the soil probe from reaching the bottom of the roots. In those cases, the auditor determines the soil type and tells the participant that their root depths are at least as deep as the soil probe measured.

Auditor using soil probe

6. Landscape Measurements

During residential inspections, the auditor measures the square footage of property's irrigable landscape. Landscape measurements are later compared with participant water records to determine how much water was being applied to the landscape; for these results, please see the watering practices section below. Landscape measurements are split between two categories: turf and non-turf.

Auditor taking landscape measurement

7. Determine Watering Schedule

Using the precipitation rate and soil type from earlier tests, the auditor uses a chart to determine a watering schedule for each of the areas tested. Watering schedules are based on a historical evapotranspiration rate of 27 inches per year in the Denver metro area. For a detailed discussion of how watering schedules are calculated, please see the watering schedule section below.

Auditor doing calculations

8. Share Test Results and Recommendations

After completing all of the tests and calculations, the auditor shares the results with the participant. For residential properties, the auditor talks through the results with the homeowner and leaves several worksheets and resources detailing the findings and recommendations. If necessary, the auditor will show the homeowner how to program their control clock. For large properties, the auditor compiles a more formal, written report, which is sent to the property manager. Auditors also recommend a variety of resources to the participant, including Colorado State University Extension's gardening factsheets and Master Gardener program. An example of the form a homeowner receives is included as an Appendix to this report. A sample large audit report is attached as appendix D.

Auditor explaining findings to homeowners

III. Results

The CRC tested 136 residential properties and 4 large properties in 2009 for Town of Erie.

Property Information

Houses had an average of 2.95 residents in the summer and 2.91 residents in the winter. The median house was built in 2002, and the median sprinkler system was installed in 2003. Residents had lived in their homes for a median of 3 years.

Landscape Size

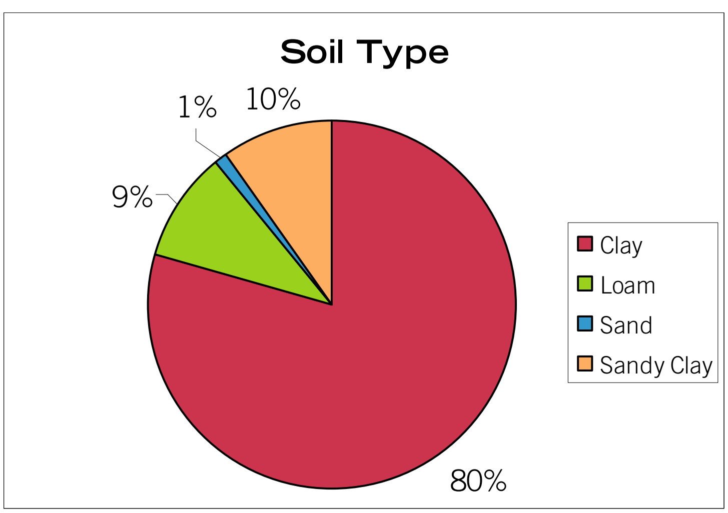
CRC auditors measured irrigable landscape sizes on residential properties using measuring wheels at the time of each inspection. The median residence had approximately 2379 square feet of turf and 2102 square feet of non-turf.

Residential Landscape Size (sq. ft.)			
	Turf	Shrub	Total
Median	2379	2102	4700
Mean	3050	2661	5681

Note: There is some discrepancy between the sum of the median turf and shrub landscape sizes and the median total. The calculation of a median does not transfer through addition: median(A)+median(B) does not have to equal median(A+B). This can be explained through difference in the composition of the subgroups A and B, especially when one of the subgroups contains some zero values.

Soil Type and Root Depths

CRC auditors took soil core samples of each zone for which they did efficiency tests – generally two zones for residential properties and 4 to 10 zones for large properties. Soil types were tested using the "feel method" and categorized as clay, loam, sand, or sandy clay.



Why does clay soil matter?

Being that a large majority of participants have clay soils, it is important to understand how to efficiently irrigate with that soil type. People with clay soils need to use a watering technique called '**cycle and soak**' irrigation to prevent runoff. Clay absorbs water very slowly, but most sprinkler systems have high precipitation rates that apply water very quickly. As a result, sprinklers often apply water more water than the soil can absorb in a given amount of time, the water then runs off, often into the gutter.

Soil Type	
Clay	80%
Loam	9%
Sand	1%
Sandy Clay	10%

CRC auditors also measured root depths using a soil probe in each zone for which they did efficiency tests. However, the hard clay soil of most zones often prevented the probe from reaching down to the bottom of the grass roots, and most root depth readings were shallower than the actual root depths. Because of this issue, root depths are not presented here.

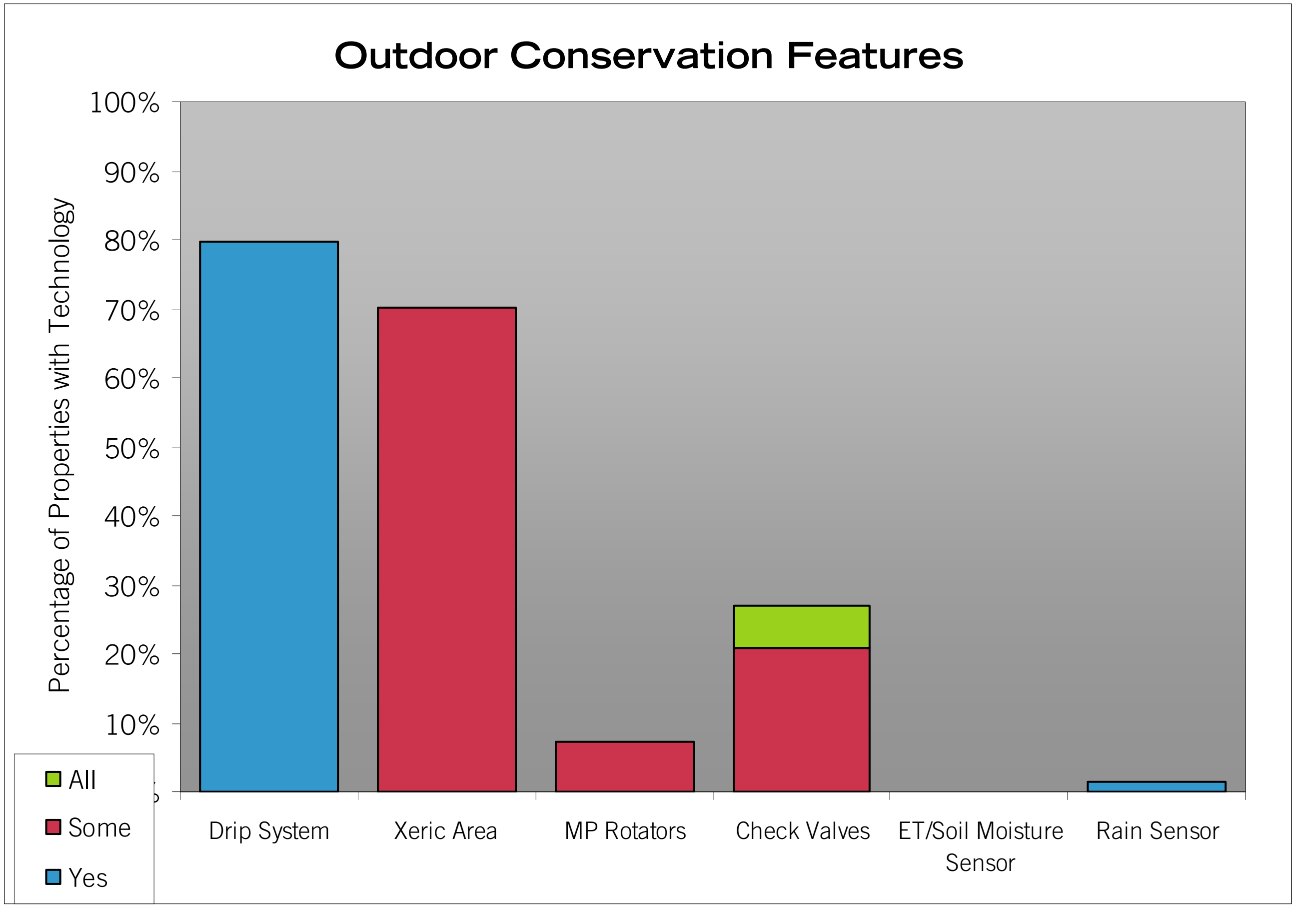
Cycle and soak irrigation involves watering for several short cycles, separated with time for the water to soak in. For clay soils the CRC recommends breaking up watering into three cycles: instead of watering for 21 minutes for the average spray zone, the CRC recommends watering for 3 cycles of 7 minutes, with an hour in between each cycle. Such cycles are easy to set with most control clocks using the multiple start times function.

Cycling saves a significant amount of water that would otherwise be lost to runoff. It also helps encourage deeper root depth (and healthier lawns), and reduces nonpoint source pollution from runoff.

Water Conservation Features: Outdoor and Indoor

Outdoor Conservation Features

The CRC looked at six outdoor features that help homeowners conserve water. CRC auditors asked both homeowners and property managers if they had a given feature, and looked for that feature during the audit. The CRC looked at outdoor conservation features for both residential and large properties. Individual features are explained below the results section.



Outdoor Conservation Technologies			
	All	Some	None
Xeric Area	1%	70%	29%
MP Rotators	1%	7%	91%
Check Valves	6%	21%	73%
		Yes	No
ET or Soil Moisture Sensor		0%	100%
Rain Sensor		1%	99%
Drip System		80%	20%

Some of the differences between the relative prevalence of outdoor conservation features may be explained by how well-known each of these features are to the participant type. Drip systems and the idea of 'xeriscape' or 'xeric' are reasonably well-known terms and ideas. We also see these features are not only prevalent; the CRC auditor reported seeing a greater number of residences with these features that were seen in 2008. Specific technologies like MP rotators and ET sensors are somewhat less well known to the general public and the CRC saw fewer of them this summer than drip systems and xeric areas. As this technology becomes better known in the landscape community, we expect to see an increase of properties installing them.

Features Surveyed

Drip System: Drip irrigation is a type of low-flow irrigation that is an efficient and effective way to irrigate many non-turf areas. A system usually includes a timer, filter, pipes, drip emitters, and sometimes micro-sprayers. Standard drip systems work well for most non-turf areas, especially flower and food gardens. Standard drip systems are not a good way to irrigate turf, but some sub-surface drip systems can irrigate turf. CRC auditors looked at whether or not there was a drip system on the property, regardless of its size.

Xeric Area: A xeric area is an area of a landscape that is planted with low or zero water plants. There are many stunning flower gardens that are xeric, and xeric areas are a key element of Xeriscape design principles. CRC auditors looked at whether a property had no xeric areas, some xeric areas, or all xeric areas. Since Slow the Flow is designed for people with sprinkler systems that water grass, our results may have under-sampled houses with all xeric areas.

MP Rotators: MP Rotators are a newer type of sprinkler head that keep matched precipitation rates as each head's arc and radius are adjusted. They save water in two ways: they water more evenly (and generally result in a higher DU) than most sprinkler heads, and they have lower precipitation rates than most spray heads do, making it easier to avoid runoff. CRC auditors looked at whether a property had no MP rotators, some MP rotators, or all MP rotators. MP rotators can be easily retrofitted onto many spray zones by exchanging nozzles.

Check Valves: Check valves are valves on sprinkler heads that prevent water in system pipes from draining out of the heads once the system has been turned off. They save water by allowing this water to be used for the next watering, instead of draining out of the lowest elevation head. They also reduce runoff, as the water from inside the sprinkler system stays there. CRC auditors looked at whether a property had check valves on none of the heads, some of the heads, or all of the heads.

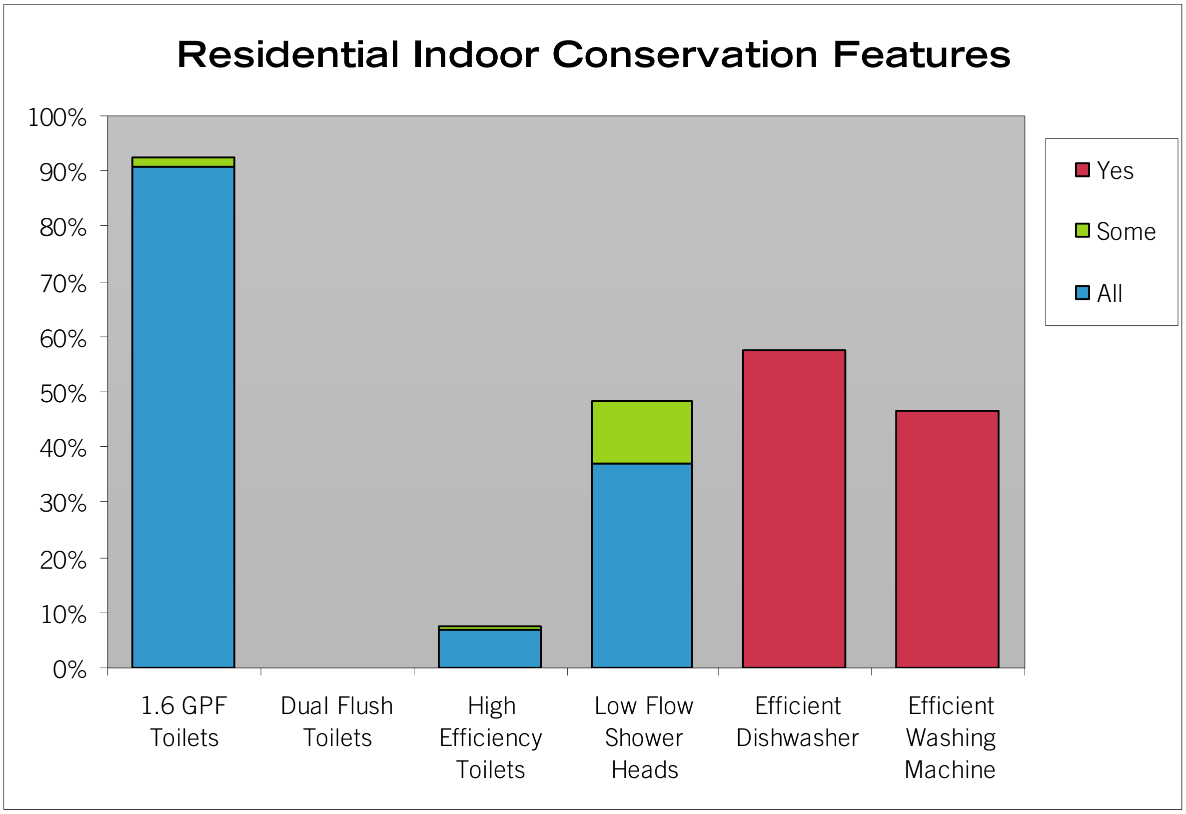
Evapotranspiration Controller or Soil Moisture Sensor (abbreviated as ET/Soil Moisture Sensor on tables): These control clocks coordinate watering times and duration with either evapotranspiration data from a weather station or the moisture level in the soil. When used properly, this can be the most efficient way to set a watering schedule, as plants can get exactly the amount of water that they need when they need it. CRC auditors looked at whether or not a property had either an evapotranspiration controller or a soil moisture sensor.

Rain Sensor: A rain sensor is a device that shuts off or delays a sprinkler system's operation if it is raining or has recently rained. They generally measure the amount of rain that falls, and delay watering an appropriate amount of time based on that amount. When used properly, they avoid having a sprinkler system run if it is raining or has recently rained a significant amount. CRC auditors looked at whether or not a property had a rain sensor installed and in use.

Indoor Conservation Features

The CRC analyzed six features that aid in indoor water conservation for residences. The CRC did not assess indoor features for large properties because of the varying nature of that property type. CRC auditors asked residents whether they had each of the features; due to time and safety constraints, auditors did not verify residents' responses. It was clear from CRC interactions with participants that a large amount of confusion about what the different features are still exists among residential homeowners. Because of this, the data may be vulnerable to confusion from participants about what exact features they have. Features are explained below the results section.

Results



Indoor Conservation Features				
	All	Some	None	Don't Know
1.6 Gallon Toilets	91%	2%	7%	1%
Dual Flush Toilets	0%	0%	98%	2%
High Efficiency Toilets	7%	1%	91%	2%
Low Flow Shower Heads	37%	11%	34%	18%
		Yes	No	Don't Know
Efficient Dishwasher		57%	38%	5%
Efficient Washing Machine		46%	39%	14%

Overall, people seem to be aware of the idea of efficient toilets, showerheads, washing machines, and dishwashers. People do not seem to be aware of dual flush toilets. A considerable percentage of people do not know what type of shower head or washing machine they have.

Toilets: There are many types of toilets that use different amounts of water. Before the early 1990s, most toilets used between 3.5 and 7 gallons of water per flush (gpf). The Energy Policy Act of 1992 mandated that all toilet fixtures installed from 1994 onwards use at most 1.6 gpf. Since 1992, two more efficient toilet types have emerged. Dual flush toilets flush different amounts of water depending upon the strength of flush needed, and high efficiency toilets (HETs) use 20% less water than the mandated 1.6 gpf toilets.

CRC auditors asked residents whether they had all, some or none of three toilet categories: standard 1.6 gpf toilets, dual flush toilets, and HETs. Many residents may have confused HETs with standard 1.6 gpf toilets, and the numbers for HET toilets should be viewed with caution.

Low Flow Shower Heads: The Energy Policy Act of 1992 also mandates that shower heads installed after 1994 use 2.5 gallons per minute of water or less at a pressure of 80 PSI. The CRC refers to these shower leads as 'low flow.' As well as saving water, low flow shower heads save significant amounts of energy, as less water needs to be heated up.

Efficient Washing Machines: Some washing machines use less water than others. The EPA's Energy Star program requires that washing machines must have a water factor (water consumption per cubic foot of washer space) below a certain level in order to achieve Energy Star certification. CRC auditors asked customers whether or not their washing machine was 'efficient.'

Efficient Dishwasher: Some dishwashers use less water than others. The EPA's Energy Star program rates dishwashers based on their energy consumption; however, this calculation includes an indirect measure of hot water consumption. CRC auditors asked customers whether or not their dishwasher was 'efficient.'

Sprinkler System Information

CRC auditors performed efficiency tests on a total of 314 zones in Erie in 2009. Of those, 187 efficiency tests were performed on spray zones, and 127 on rotor zones.
A full breakdown follows:

Distribution Uniformity (DU)

CRC auditors tested the distribution uniformity of all or part of each zone using the lower-quartile method. Distribution uniformity is a measure of how evenly an irrigation system waters the property. It is reported as a percentage, from 0% to 100%. The Irrigation Association considers a DU value of over 70% as acceptable for rotor zones, and one of over 55% as acceptable for spray zones. However, for the purposes of this analysis, the CRC holds both head types accountable to the higher standard of 70% DU and only considers zones acceptable if they meet that level. The CRC considers values between 40% and 70% as substandard, and less than 40% as unacceptable.

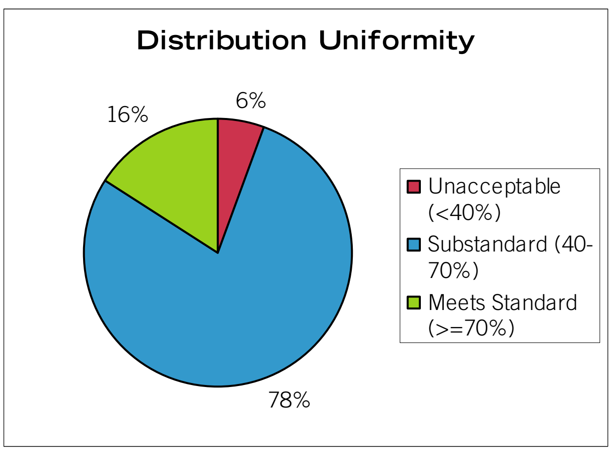
Many factors influence distribution uniformity values. The original design and installation of the system – head choice spacing, placement, and system pressure and system maintenance (fixing broken or tilted heads), nozzle choice, and head replacement choices are the major factors that affect DU.

There are a few principles that will help keep distribution uniformity high. The system should be designed with head-to-head spacing: the spray from one sprinkler head reach the base of the next head. The sprinkler heads and nozzles in the system should be as uniform as possible; different brands and models of heads and nozzles have different spray patterns, and similar spray patterns yield high DU values. The system should operate at pressures within the head manufacturer's recommended range. Finally, the system should be regularly maintained and inspected, and problems should be fixed.

Distribution uniformity values do affect peoples watering schedules and watering times. If a zone has a low DU value, some sections of it will get much more water than others. A watering schedule that waters the correct amount for the zones as a whole will not provide enough water for zones with a low DU, resulting in brown grass. When this happens the homeowner or irrigation manager will usually increase the watering time for that zone to give the brown area enough water. This would result in all of the other parts of the zone being overwatered, and the area that gets the least water will have just enough. In short, people tend to apply water based on the needs of the driest part of the landscape.

Many areas are overwatered because of this problem. The CRC instructs its auditors not to give a watering schedule in cases when the DU value is less than 40%, as the CRC schedule would leave brown spots on the lawn. However, CRC auditors usually have concrete suggestions on how to improve low DU values.

Exactly what a homeowner or property manager should do to improve a low DU value depends on the source of the problem. A low DU value often occurs because of maintenance problems, like sunken or tilted heads. In those cases, the problem can be fixed by simple things like raising and straightening the heads. Sometimes, incorrect nozzles or non-uniform heads cause the problem, and can be fixed by replacing the incorrect parts. Occasionally, the problem stems from poor system design and the auditor will recommend a system redesign.



Distribution Uniformity			
All Properties	Unacceptable (<40%)	Substandard (40-70%)	Meets Standard (>=70%)
Spray	7%	83%	10%
Rotor	4%	74%	22%
Total	6%	79%	15%

Distribution Uniformity Statistics			
All Properties	All Zones	Spray Zones	Rotor Zones
Median	60.5%	54.0%	60.5%
Mean	67.0%	52.6%	59.4%
Range	6-89%	6-83%	22-89%

Rotor zones tend to have significantly higher DU values than spray zones, across all property types.

The Irrigation Association has released updated audit guidelines in November of 2009. The revised guidelines calculate distribution uniformity values in decimal points and were adopted to simplify the development of irrigation schedules and make the language more consumer friendly. Previously, distribution uniformity was expressed as a percentage. Because 100 percent typically represents optimal performance, systems that performed well by industry standards were often underrated by consumers and regulatory agencies. For example, most irrigation professionals would classify a spray zone with a distribution uniformity value of 70 percent as outstanding, and one with a DU of 65 percent as very good. In contrast, the general public generally equates 65 percent with a “D” or barely passing grade. Under the new guidelines, a DU of 0.70 would be considered outstanding, and one of 0.65 would be viewed as very good. The change has no mathematical implications. The CRC will implement this change in the 2010 auditing season.

System Pressure

In each of the zones tested, CRC auditors measured the operating pressure of one or more of the sprinkler heads. On rotor zones, pressures were tested by inserting a pitot tube to the main stream of water coming out of the head. In years past auditors measured the pressure of spray heads by removing the nozzle, attaching a pressure gauge, and turning the zone on. In 2009 the CRC decided to improve this method, in hopes of getting a more accurate psi measurement. The previous method of blocking all water from one head in the zone could artificially raise the operating pressure of that zone by up to 5 PSI. The CRC purchased pressure-T’s that allow water to continue running out of the head while also taking the pressure.


2008 Method


2009 Method

The methods auditors use to test pressure work well for most sprinklers, but in some instances the CRC is unable to test the pressure due to incompatible pressure gauge attachments with certain types of sprinklers. For those zones, auditors could not test pressure, but can make visual observations about pressure levels.

Sprinkler heads are designed to operate within a given range of pressures. Most spray heads are designed to operate between 20 and 30 pounds per square inch (PSI), and most rotor heads are designed to operate between 25 and 80 PSI.

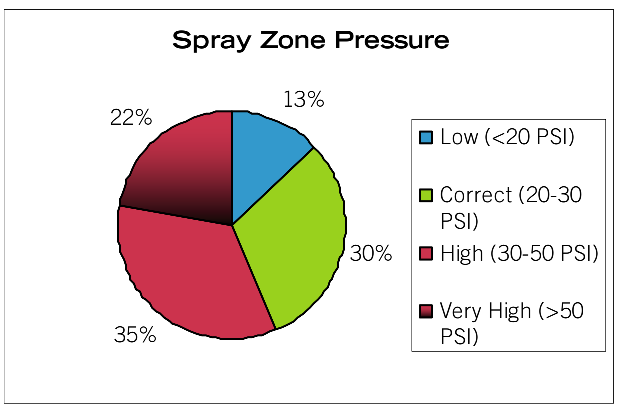
The actual pressure at which heads operate depends on several factors, and is often very different from the designed operating pressure. Factors that influence operating pressure include the pressure of the line coming into the system, the presence of pressure regulators, the design and number of heads on the zone, the amount of water that each head emits, and any leaks that are present on the zone.

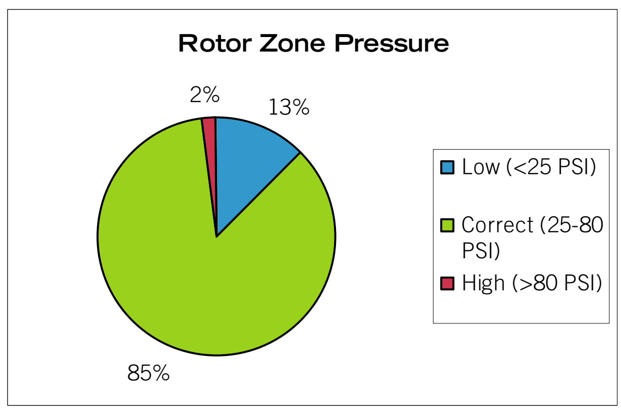
Several problems arise when operating pressure is different from design pressure. Operating pressure that is too high results in wasted water, potential overspray, and increased system wear. When pressure (especially on spray zones) is too high, the water droplets often spray out in a fine mist; as the mist hangs in the air, it evaporates and can be blown away by the wind. Exact evaporation rates depend on temperature, humidity and wind, but according to industry representatives, the amount lost can be significant.

High pressure problems can often be fixed fairly easily. Depending on the extent of the problem, one of two approaches can be used. For small problems, pressure regulating stems can utilized on individual heads. For more systematic issues, pressure reducers can be installed on specific zones on or an entire sprinkler system.

While high pressure causes water waste and unnecessary system wear, low pressure mostly impacts coverage and distribution uniformity. When pressure on a head is below the design pressure, the head may not operate as intended. The coverage pattern can be different than designed, the head may not spray as far as it was intended to, or in extreme cases, heads may not pop up at all. Extremely low pressures are often a warning sign of leaks on a zone.

Low pressure problems are harder to fix than high pressure problems are. If the low pressure is caused by a leak, repairing the leak will usually fix the problem. If the problem is not caused by a leak, zones can be split so that each zone contains fewer heads, or the system can be redesigned in a similar manner, perhaps using a different type of head that requires lower pressure to operate. Sometimes running the system at a time when other water users in the neighborhood are not running their systems can raise the pressure.





Spray Zone Pressure (%)				
	Low (<20 PSI)	Correct (20-30 PSI)	High (30-50 PSI)	Very High (>50 PSI)
All Properties	13%	30%	34%	22%

Rotor Zone Pressure (%)			
	Low (<25 PSI)	Correct (25-80 PSI)	High (>80 PSI)
All Properties	13%	85%	2%

Spray Zone Pressure Statistics (PSI)	
	All Properties
Median	35.0
Mean	38.1
Range	5-90

Rotor Zone Pressure Statistics (PSI)	
	All Properties
Median	34.5
Mean	37.0
Range	12-85

Spray pressures were above design specifications, with an average of 38.1 PSI, well outside the recommended 20-30 PSI range. 22% of spray zones had very high pressures of over 50 PSI. Rotor pressures averaged 37 PSI, within 25-80 PSI recommended range. Rotor heads have a much broader range of acceptable pressures than spray heads, and the proper pressure depends on the make and model of the head.

Precipitation Rates

As part of the catch-cup test in which auditors calculate a zone's distribution uniformity, CRC auditors also calculate the precipitation rate for that zone. A zone's precipitation rate is the amount of water that falls on a given point in the zone over a certain amount of time, usually expressed in inches per hour. Precipitation rates are less of a measure of the efficiency of a sprinkler system than distribution uniformity and pressure, and are used more often to calculate watering schedule.

The CRC's watering schedule, which will be explained in-depth below, recommends applying ½ an inch of water during each watering of bluegrass. By dividing 0.5 inches by the precipitation rate, an auditor or homeowner can determine how long it takes to apply ½ an inch of water. For example, if the precipitation rate was 1 inch per hour, one would need to water for ½ an hour, or 30 minutes, to apply 0.5 inches of water to the grass. CRC auditors use this as part of their calculations to recommend a watering schedule.

There is one aspect of precipitation rates than can help people avoid wasting water: lower precipitation rates tend to result in less runoff. The Front Range's clay soils absorb water very slowly. When water is applied at a high rate, much of that water will begin to run off after a few minutes. Residents and property managers can fix this by using 'cycle and soak' scheduling techniques, described below, but lower precipitation rates mean that people uneducated about irrigation scheduling waste less water.

Spray Zone Precipitation Rates (Inches/Hour)	
	All Properties
Median	1.47
Mean	1.52
Range	0.32-3.5

Rotor Zone Precipitation Rates (Inches/Hour)	
	All Properties
Median	0.87
Mean	0.81
Range	0.13-2.15

Watering Schedules

CRC auditors recommend a watering schedule at each audit. The watering schedule is based on an average historical evapotranspiration rate of 27 inches per year in the Denver area. It recommends applying ½ an inch of water at each watering, and watering for 1-3 days per week, depending on the month and severity of temperatures. Exact watering times depend on soil type and precipitation rate.

CRC auditors use the following two charts to recommend watering schedules. It is worth noting, that, as discussed in the soil type section above, CRC auditors recommend cycle and soak irrigation in nearly every schedule.

How Often to Water

Month	Days per week	Minutes depend on Precipitation Rate
April	Spring	
May	1.5	
June	2	
July	2*	
August	2*	
September	1	

*In July and August, days per week can increase to 3 times in a non-drought year

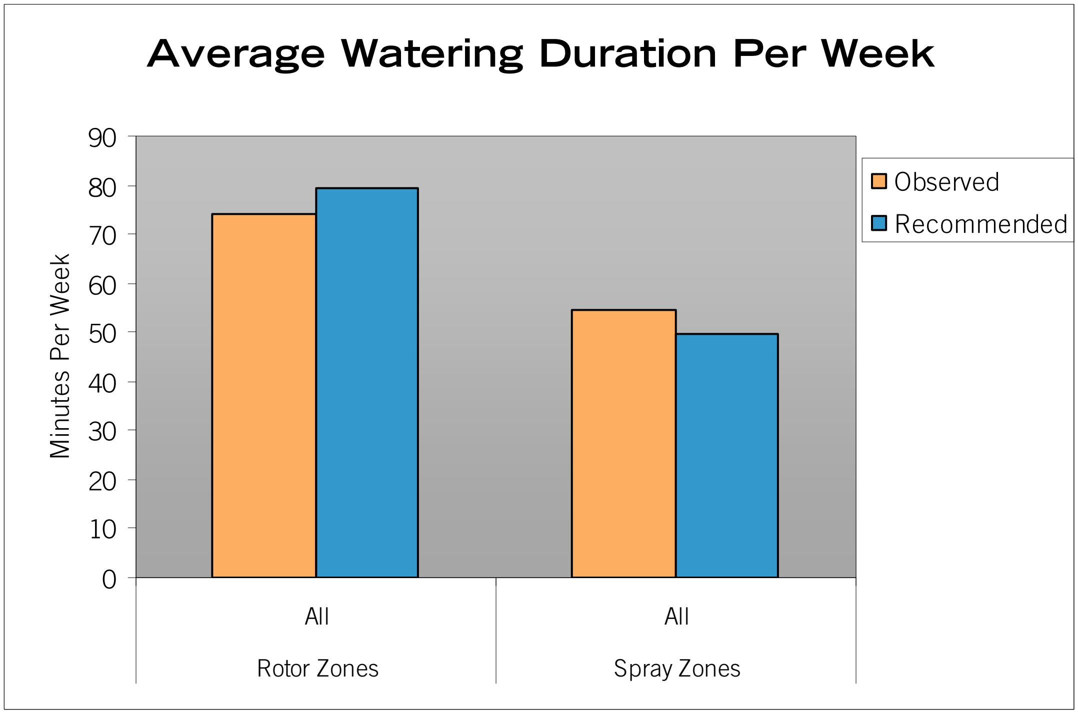
How Long to Water
Based on Soil Texture

Time Required To apply 1/2 Inch of Water

Precipitaion Rate (Inches Per Hour)	Clay Soils (Cycles) x Minutes	Loam Soils (Cycles) x minutes	Sandy Soils minutes
4.0	(3) 3	(2) 4	8
3.5	(3) 3	(2) 5	9
3.0	(3) 3	(2) 5	10
2.5	(3) 4	(2) 5	12
2.0	(3) 5	(2) 7	15
1.5	(3) 7	20	20
1.4	(3) 7	21	22
1.3	(3) 8	23	24
1.2	(3) 8	25	25
1.1	(3) 9	27	27
1.0	(3) 10	30	30
0.9	(3) 12	33	35
0.8	(3) 14	37	40
0.7	(3) 15	43	45
0.6	(3) 17	50	50
0.5	(3) 20	60	60
0.4	(3) 25	75	75
0.3	(2) 50	100	100
0.2	(2) 75	150	150

In some cases, a homeowner has been underwatering their lawn but is happy with its state. In those cases, CRC auditors often recommend that the homeowner keep watering with the current schedule, but that they implement cycle and soak irrigation if necessary.

The CRC recommends that homeowners and property managers ease into watering schedules, especially if they have been overwatering. Plants can adapt to a range of water amounts, but they do not react well to a sudden change in water. CRC auditors often recommend that people switch to cycle and soak irrigation immediately and then ease into a new watering schedule over a period of a few weeks to a month.



Residential participants tended to water spray zones for slightly more than CRC auditors recommended, and to water rotor zones for somewhat less than recommended.

Because rotor zones usually have lower precipitation rates, they should be watered for longer than spray zones. It appears that most participants recognize this, and water their rotor zones for somewhat longer than spray zones. Residential participants, especially, may not be aware of the magnitude of the difference between appropriate spray and rotor zone watering times.

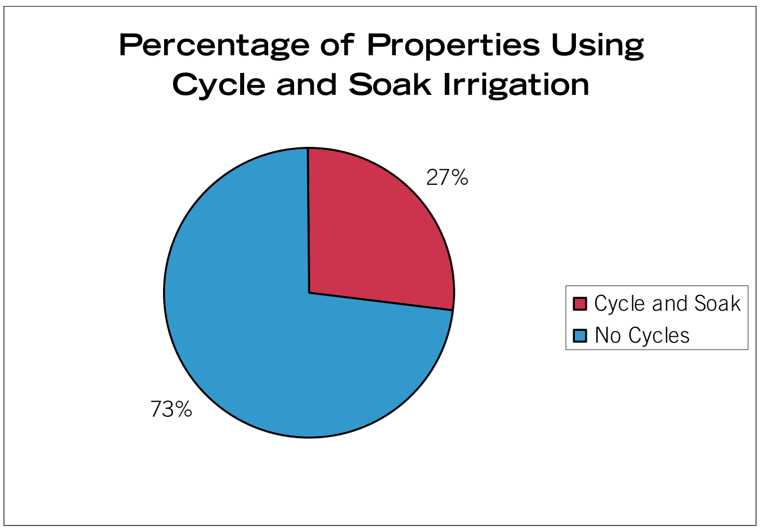
Average Watering Duration (minutes per week)		
Rotor Zones	Observed	Recommended
All Properties	74	80
Spray Zones	Observed	Recommended
All Properties	54	50

Due to an abnormally wet summer in much of Colorado, the recommended watering times in 2009 were much closer to the observed watering times than in previous years. The recommended watering times are based on evapotranspiration(ET) which calculates evaporation and transpiration based on multi-year averages. The 2009 ET values were 1.67 inches less than in 2008 and 2.35 inches less than 2007. The CRC found that most people recognized that their watering need as not as great due to the lower temperatures and frequent rains. There were still significant differences in recommended and observed watering times in spray zones.

Cycle and Soak Irrigation

As mentioned in the soil type section, cycle and soak is an important irrigation scheduling technique for clay soils. Since the vast majority of soils in the Front Range are clay, CRC auditors recommend cycle and soak in nearly every inspection.

Auditors looked at whether participants were implementing cycle and soak irrigation, and how many cycles participants used if they were using this technique. Properties were classified as using cycle and soak irrigation if they were watering in two or more cycles. Many of these properties were using cycles separated by much more than one hour (half in the morning and half at night, for example). Such techniques are not ideal, as they do not include the deep watering benefits of correct cycle and soak techniques. They are, however, significantly better than no cycles at all.



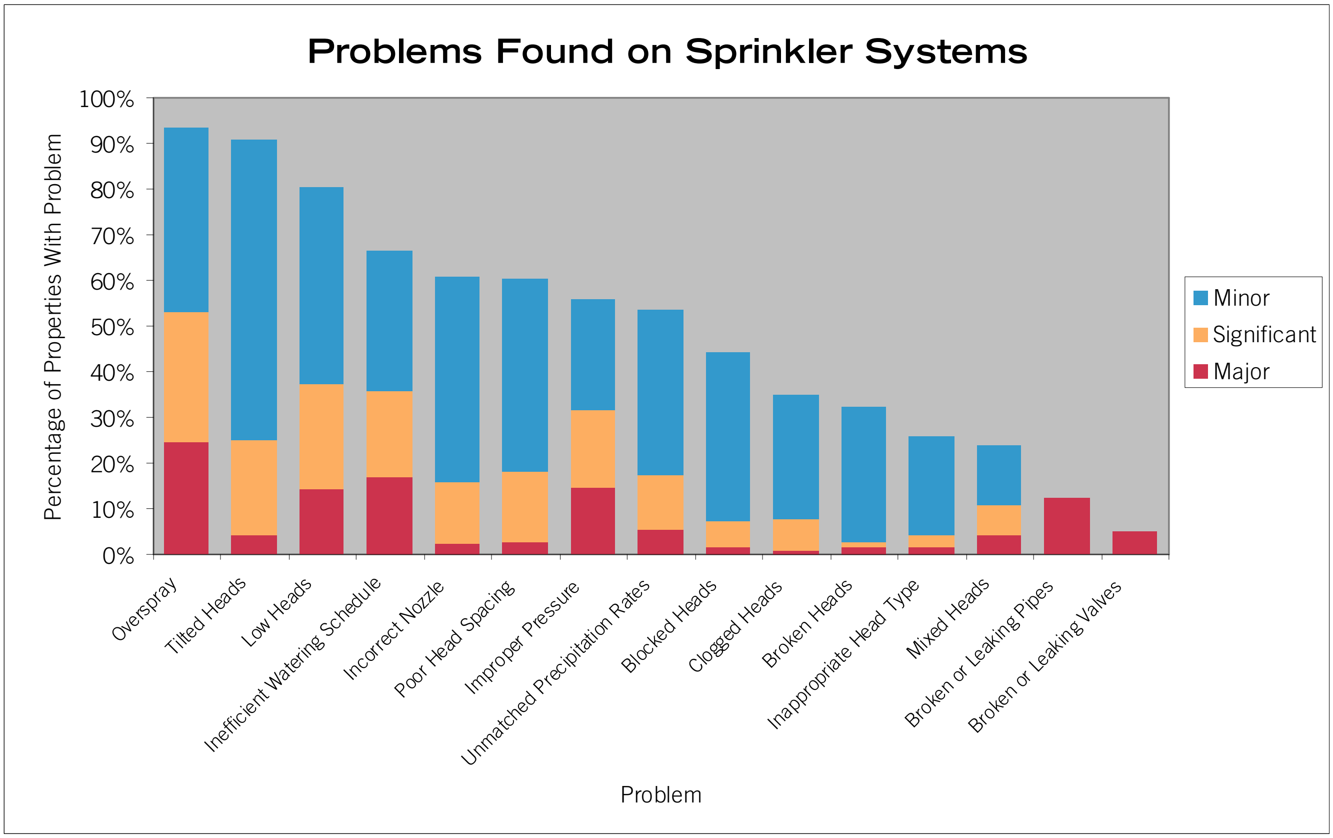
Percentage of Properties Using Cycle and Soak Irrigation	
All Properties	27%

"Many properties were using cycles separated by much more than one hour… such techniques are not ideal."

Many properties did not use cycle and soak irrigation. Anecdotal evidence from CRC auditors suggests that people are not aware of cycle and soak irrigation; once the concept is explained to people, they tend to embrace it. Cycle and soak irrigation is an ideal target for an education campaign; it has substantial benefits including: reduced water waste, reduces non-point pollution, creates healthier landscapes and is very easy to implement.

Problems Found on Sprinkler Systems

CRC auditors tracked what problems they found during each inspection, and the severity of each problem. Auditors tracked 15 of the most common problems, which are each defined below. Auditors classified problems as none, minor (occurring on less than 20% of the property), significant (occurring on 20-50% of the property), and major (occurring on more than 50% of the property). Two problems, broken or leaking pipes and broken or leaking valves, were rated as either yes (there was a break or a leak), or no.



Problems Found - All Properties				
	Major	Significant	Minor	None
Overspray	24.46%	28.78%	40.29%	6.47%
Tilted Heads	4.29%	20.71%	65.71%	9.29%
Low Heads	14.39%	23.02%	43.17%	19.42%
Inefficient Watering Schedule	17.07%	18.70%	30.89%	33.33%
Incorrect Nozzle	2.14%	13.57%	45.00%	39.29%
Poor Head Spacing	2.88%	15.11%	42.45%	39.57%
Improper Pressure	14.52%	16.94%	24.19%	44.35%
Unmatched Precipitation Rates	5.45%	11.82%	36.36%	46.36%
Blocked Heads	1.43%	5.71%	37.14%	55.71%
Clogged Heads	0.71%	7.14%	27.14%	65.00%
Broken Heads	1.44%	1.44%	29.50%	67.63%
Inappropriate Head Type	1.44%	2.88%	21.58%	74.10%
Mixed Heads	4.32%	6.47%	12.95%	76.26%
Leaks	Yes	No		
Broken or Leaking Pipes	12.32%	87.68%		
Broken or Leaking Valves	5.07%	94.93%		

The problems examined by the CRC can roughly be split into two categories: maintenance and design. Although there is some overlap between the two, overspray, low heads, tilted heads, inefficient watering schedule, blocked heads, clogged heads, broken heads, and both types of leaks can be considered maintenance problems. Improper pressure, poor head spacing, incorrect nozzle, unmatched precipitation rates, mixed heads, and inappropriate head type can be considered design problems. Some of the individual problems and patterns will be examined below.

Overspray was the most common problem, found on over 94% of all properties. Overspray problems can often be fixed by changing nozzles to ones with more appropriate or adjustable arcs. More serious overspray problems sometimes require replacing heads or redesigning a zone.

Inefficient watering schedules are often fixed during an inspection.

Low heads, tilted heads, and blocked heads can be fixed with regular maintenance to the system. All three of these problems are easy to spot by doing a visual inspection of the sprinkler system while it is turned on. They can be fixed by a do-it-yourself oriented homeowner or by a professional sprinkler company.

Pressure problems were generally more significant than other problems – if a property had a pressure problem, it was usually a significant or major problem. Pressure problems are usually systematic – they affect an entire zone, or an entire class of zones, or an entire property.

Participant Watering Practices

The CRC analyzed water billing data for residential program participants to determine participants' watering practices before receiving an audit. Using participants' landscape size, as measured during each inspection, the CRC was able to compare how much water people applied to their landscapes to evapotranspiration (ET) values for turf and non-turf.

Methodology

The CRC considers the months of May through September as outdoor irrigation months, and October through April as indoor months with little or no irrigation required. The CRC determined outdoor usage by averaging usage during the indoor months and subtracting that from usage during the outdoor months. Outdoor usage was then compared to landscape size to determine how much water, in inches, the homeowner applied to the landscape during the irrigation season.

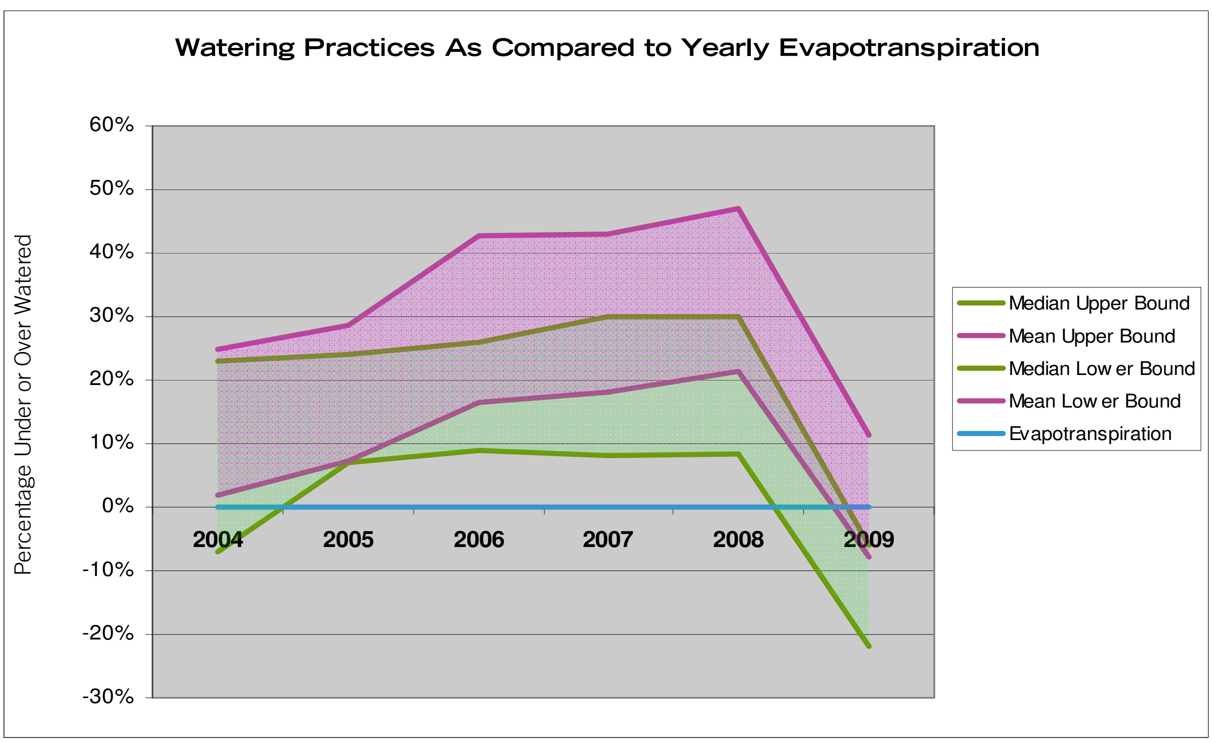
The CRC then calculated an ET value for each home using yearly ET values for the Denver Metro area and the proportions of turf and non-turf areas of landscape on each property. Yearly ET values for bluegrass are based off of readings from local weather stations and are listed below, with the results. In previous years the CRC assumed that non-turf areas should be watered at roughly 2/3 of the amount of water that turf received. This assumption is based off of a 2004 study conducted by the Northern Colorado Water Conservancy District and Colorado State University that looked at ET requirements for common shrubs found in landscapes along the Front Range.

In 2009; however, changes in auditor training unintentionally altered the way landscape sizes were measured. The CRC auditors measured all permeable surfaces, regardless of if the area was currently being watered or had any vegetation. This resulted non-turf areas being significantly larger than previous years and turf landscapes sizes being comparable. When the CRC initially ran the calculations with non-turf areas using 2/3 as much water as turf areas, watering practices from 2009 participants were not comparable to participants from 2008. The CRC ran the calculations a second time using 1/3 for the variation in non-turf and turf watering needs. The two calculations are shown in the table below and the CRC believes that the actual watering practices of the participants are contained in the shaded area between the two means and medians.

The inches of water that the homeowner applied to the landscape sizes were then compared to ET. Data is reported as a percentage above or below ET. A property that watered at 120% of ET is reported as having overwatered by 20%. A property that watered at 70% of ET is reported to have underwatered by 30%.

While this method gives helpful results, it is not perfect and the results should be viewed as somewhat approximate. The technique of averaging the indoor usage and subtracting it from outdoor months is an approximate way to determine outdoor usage. Additionally, many people water during the months of October and April, even though their lawn may not need it. ET rates, turf types, and shrub types, differ between houses, and different areas of the landscape receive different amounts of water. The CRC did not calculate watering practices for large properties because of the challenges involved in determining outdoor water usage of different types of large properties.

Results



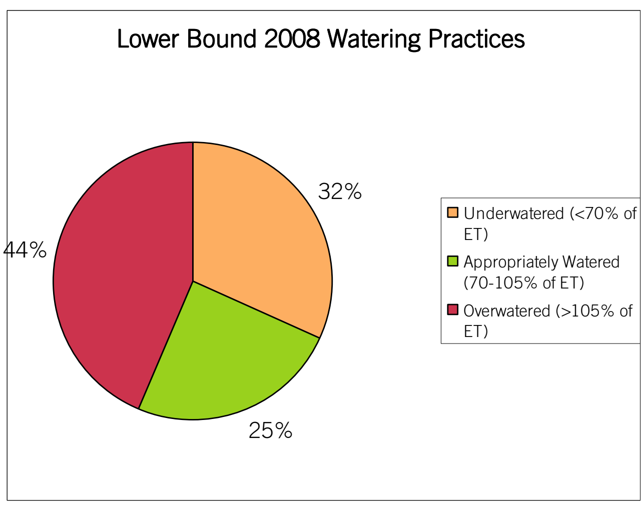
Watering Practices As Compared to Yearly Evapotranspiration (ET)						
Year	2004	2005	2006	2007	2008	2009
Median Upper Bound	23%	24%	26%	30%	30%	-6%
Mean Upper Bound	25%	29%	43%	43%	47%	11%
Median Lower Bound	-7%	7%	9%	8%	9%	-22%
Mean Lower Bound	2%	7%	17%	18%	21%	-8%
ET (inches of water)	20.38	24.25	23.89	24.16	23.48	21.81

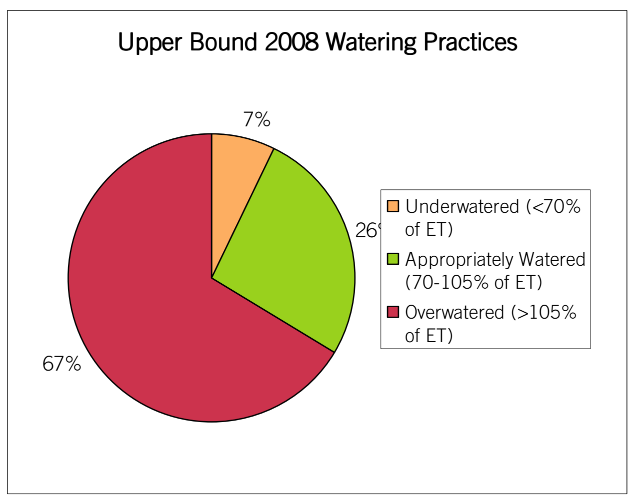
It is important to note that this data includes the watering practices of properties audited in 2009, and their watering practices from 2004 to 2009. The data shows a possible 'drought shadow' pattern from 2004-2005. In 2002 there was a very severe drought in the Front Range. With the drought fresh in their minds, participants may have been more conscious of their water usage in 2004 and 2005. As the memories of the drought faded, water usage returned to a steady level from 2006 to 2008. Additionally the data shows that participants reacted strongly to wetter weather in 2009 by actually under watering their turf.

CRC considers the most accurate representation of people's current watering practices before they receive an inspection as the 2008 data. In 2009, people received inspections from June through early September. The information and watering schedule that they received during the inspection may have changed their watering practices for the remainder of the summer.

2008 Breakout

The CRC split participants up into three groups based on their 2008 watering practices: participants who underwatered, watered appropriately, and overwatered. A study by Brent Mecham at the Northern Colorado Water Conservancy District found that bluegrass responded well to water amounts as low as 70% of ET. The CRC used this information to classify underwatered as watered by at least 30% under ET, watered appropriately as watering between 30% under and 5% over ET, and overwatered as watered at more that 5% over ET.





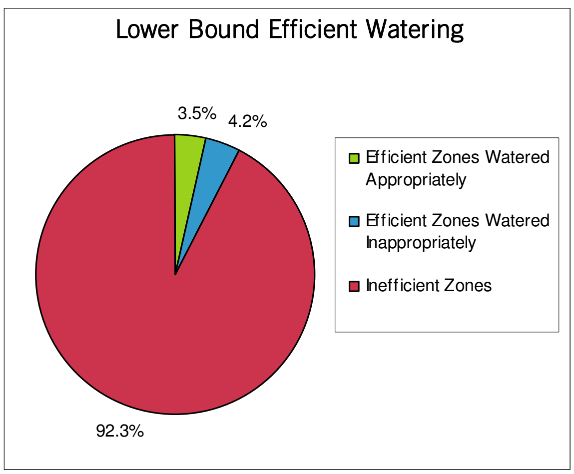
Lower Bound 2008 Watering Practices		
Underwatered (<70% of ET)	Appropriately Watered (70-105% of ET)	Overwatered (>105% of ET)
32%	25%	44%

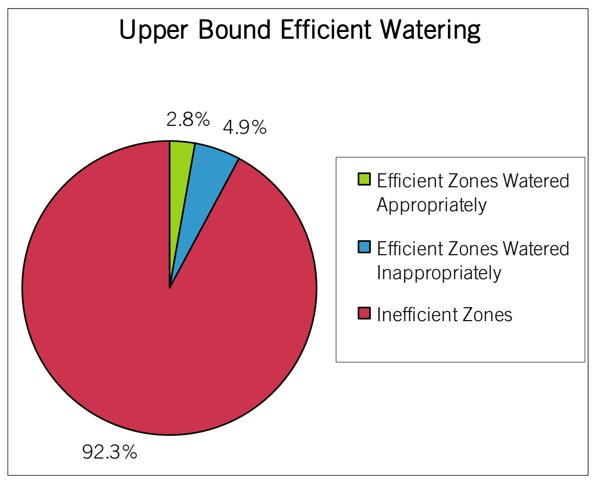
Upper Bound 2008 Watering Practices		
Underwatered (<70% of ET)	Appropriately Watered (70-105% of ET)	Overwatered (>105% of ET)
7%	26%	66%

Efficient Watering

Measures of how well a sprinkler system is used, needs to incorporate both watering practices and sprinkler system efficiency. A homeowner may water appropriately as defined above, but if their system has a low DU value or is operating at the wrong pressure, the grass may not be healthy and they may be wasting water. Conversely, a system may be operating with a high DU value and at the right pressure, but if it turned on for the wrong amount of time, water may be wasted or the lawn may be unhealthy.

The CRC used participants DU values, pressure readings and 2008 watering practices to measure how many people were watering efficiently. Zones were defined as efficient if they had a DU value above 70% and were operating at the right pressure. The participant's 2008 watering practices were examined; if the participant watered appropriately in 2008 and a given zone was efficient, then the CRC considers that zone as efficiently watered. Please note that the dataset used in this section covers only residential properties and zones only were included if they had a DU value, a pressure reading, and 2008 watering practice information.





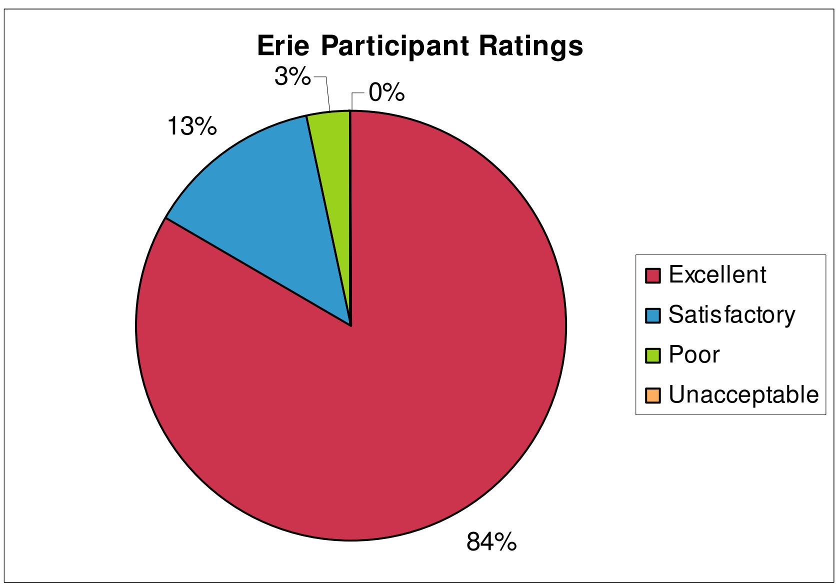
Lower Bound					Upper Bound			
	Efficient Zones Watered Appropriately	Efficient Zones Watered Inappropriately	Inefficient Zones			Efficient Zones Watered Appropriately	Efficient Zones Watered Inappropriately	Inefficient Zones
All Zones	3.5%	4.2%	92.3%		All Zones	2.8%	4.9%	92.3%
Spray Zones	1.2%	2.3%	96.5%		Spray Zones	1.2%	2.3%	96.5%
Rotor Zones	7.0%	7.0%	86.0%		Rotor Zones	5.3%	8.8%	86.0%

*Please note that this data only includes zones for which the CRC had all three pieces of information; a DU value, a pressure reading, and 2007 watering practice information.

Rotor zones were more likely than spray zones be efficiently watered. As discussed above, rotor zones had higher DU values and a wider pressure range than spray zones. However, even among efficient zones, rotor zones were more than twice as likely as spray zones to be watered appropriately. The sample size is too small to draw any hard conclusions, but the lower precipitation rates of rotor zones may have something to do with the difference.

IV. Evaluations

The CRC gave program participants evaluations of the Slow the Flow program. Most program participants were emailed a link to an online survey. For participants who did not have an email, CRC auditors left participants with a paper evaluation. The CRC received 62 responses from Erie participants, a 29% response rate. Evaluations were generally very positive.
When asked "*How would you rate your irrigation inspection?*" 78% of participants rated it excellent, and 20% rated it satisfactory.



When asked “*Did the auditor display the knowledge and skills necessary to perform the inspection effectively*?” 98% of respondents responded yes.

In an attempt to tease out themes from evaluation comments, the CRC staff made word clouds of the responses to three open ended questions in the evaluation. A word cloud is an image reflecting the prominence of different words in a set of text. Words that occur more often are large in the image. The CRC would like to thank the website www.wordle.net for this service.

These word clouds are for the evaluations received for the entire Slow the Flow Colorado Program in 2009. The CRC finds that evaluation themes are usually similar across cities.

How would you rate your inspection?

A couple of themes pop out of this word map. People were impressed by how thorough the inspection was, and thought that the auditors were knowledgeable. They received a lot of information, and they thought the inspection was professional, good, great, and helpful.

Did the auditor display the knowledge and skills necessary to perform the inspection effectively?

Themes of this cloud are similar to the previous one. Participants thought the auditor was knowledgeable and professional. Two phrases stood out: “answered all questions,” and “explained everything.”

What was most useful about the inspection? What did you learn?

By far, the most common theme that people learned was about the watering schedule; the most common words were “watering schedule,” “water,” and “watering.” People also learned about their system and sprinkler heads.

What information would you have liked to receive that was not covered?

Evaluation Comments:

Below is a small selection of comments from the evaluations.

"[The auditor] was professional, pleasant and knowledgeable."

"I loved [The auditor's] upbeat personality - she gave me great information about how to improve my system's efficiency and, more importantly, how to save money."

"I learned that a massive amount of water would be necessary to maintain a Kentucky Bluegrass lawn. It is more water (and money) than I want to spend. Seeing this audit pushes me more toward xeriscaping."

"[The auditor's] was very patient and helpful."

"It provided me with a lot of info on how to improve my system."

"Very thorough. Very professional inspector!"

"She explained to me why we should set up our sprinkler timer as she figured and taught me how to do it."

"They were thorough, and explained things clearly."

Appendix A: Homeowner Form

2639 Spruce St.
Boulder, CO. 80302
303.999.3820

What is an Irrigation Inspection?

A landscape irrigation inspection is a series of tests performed on your watering system to determine your system efficiency. This includes how much water your system puts out (precipitation rate), the soil type, which affects infiltration rate, the evenness (distribution uniformity or efficiency) of the water application and the system pressure.

Tune Up Your System

You can tune up your system by fixing the maintenance problems identified in a visual inspection. Turn the system on at least once a month and watch each zone run for a minute or so to make sure the system is working properly. Check for broken, tilted, clogged, or blocked heads and make any needed repairs. Take the time to adjust sprinklers that are not covering the desired area and learn how to change your timer.

Fixing Something? Choose a Certified Contractor

There are no statewide training or certification requirements or irrigation contractors in Colorado, although some cities have certification requirements. However, there are several organizations that provide optional certification programs, and the CRC strongly recommends using a certified contactor. For more information, please see the 'Finding a Landscaper or Contractor' section at the end of this packet.

Soil Type and Slope

Many times irrigation systems apply water faster than the soil can absorb. It is important to know your soil type and adjust your watering to minimize run-off. Slope and thatch also affect run-off.

Soil Type______________________, Slope ___________________________________

Precipitation Rate

Precipitation rate (PR) is a measure of how many inches of water per hour your irrigation system is applying. Different head types have different precipitation rates. The precipitation rate determines how long you need to run your sprinklers.

Your precipitation rate is _________in./hour in spray zones and, __________in./hour in rotor zones.

Distribution Uniformity

The distribution uniformity (DU) is a measurement of an irrigation system's ability to apply water uniformly over the surface of a landscape. Since the amount of water put out by an irrigation system is not completely uniform, some parts of the landscape will receive more water than others. Minor adjustments to most systems can improve distribution uniformity and green up the dry spots.

Your Distribution Uniformity is **_____________% Spray ______________% Rotor**.

Water Pressure

Most sprinkler heads apply water most efficiently at a water pressure between 20 and 30 PSI (pounds per square inch) for spray heads and 25-80 PSI for rotor heads. Sprinklers can't cover the desired area if the pressure is either too low or too high. If your pressure is low, try watering when less people are watering or modify your system so there are fewer sprinklers on each valve. High pressure causes misting and wears out your sprinklers faster. If your pressure is high, pressure regulating heads or a pressure regulator can be installed to lower pressure, minimize misting, and maximize irrigation efficiency.

Your Sprinkler head pressure is fixed __________psi., rotor:___________psi.

Root Depth

For a healthy lawn, roots should be 6 to 12 inches deep. This is accomplished by deep infrequent watering that greatly enhances your lawns ability to withstand extreme temperatures and increased intervals between watering.

Your root system is about ______________ inches deep.

Evapotranspiration

Evapotranspiration (ET) is one of the most important things to consider when scheduling run times for your irrigation system. ET is the amount of water a plants loses to evaporation and transpiration and is the amount of water needed for the plant to survive. Our recommended watering schedule is based on an **average historical ET** for the Denver area of 27 inches of water per year. If the weather is significantly hotter and drier or cooler and wetter than average, you may need to adjust your watering schedule.

Landscape Size and Water Usage

Your landscape has approximately _____ square feet of turf and _____ square feet of non-turf areas. Turf uses an average of 27 inches of water per year in the Denver area, and the *average* shrub bed in Colorado uses roughly 18 inches of water per year. With an efficient irrigation system, it should take roughly _________ gallons of water each year to water your landscape.

Irrigation Scheduling

The following schedule has been completed based upon your soil type, and precipitation rate as well as the historical ET rate (described above). It is meant to serve as a **guide** --- keep an eye on your lawn and make adjustments as needed. Make sure to apply seasonal adjustments while the sprinkler system is in operation.

Cycling

Watering in short cycles, or 'cycling' is important in heavy clay soils, on slopes, or when sprinklers have a high precipitation rate. Run through all zones at one-half or one-third the total time needed (see 'Cycles' on the watering schedule) then re-run the zones again by adding additional start times. This will help prevent puddling and runoff.

Recommended Watering Schedule

This schedule can be used as a GUIDE during non-restrictive years. This schedule is based on the areas of your landscape that tests were performed on. Zones that have the same head types and have other similar features can use the recommended schedule as a base starting point. Adjustments for varying microclimates, such as sun exposure, will have to be made accordingly.

SPRAY ZONES TESTED:
Current Minutes Per Week: ________ Recommended Minutes Per Week: ______

Month	Times/week	Cycles	Minutes	Total Minutes per watering	Total Minutes per week
May	1.5				
June-August	2				
September	1				

ROTOR ZONES TESTED:
Current Minutes Per Week: _______ Recommended Minutes Per Week: ______

Month	Times/week	Cycles	Minutes	Total Minutes per watering	Total Minutes per week
May	1.5				
June-August	2				
September	1				

This program is brought to you through the Center for ReSource Conservation and the following water providers:

Appendix B: Evaluation Form

Irrigation Inspection Evaluation

Dear Customer,

Thank you for your participation in the Slow the Flow Colorado Irrigation Inspection program. The Center for ReSource Conservation (CRC) strives for high quality customer service. The CRC is asking for your input to help improve the Irrigation Inspection program. Your comments are important to us. We would appreciate any feedback, positive or negative. Please answer the questions below and return the questionnaire in the enclosed envelope. If you have any questions or comments that you would prefer to discuss on the phone, please feel free to contact us at (303) 441-3278 ext. 17

Thank you,
Slow the Flow Colorado

---

1. What city do you live in?____

2. How would you rate your Irrigation Inspection?
☐ Excellent ☐ Satisfactory ☐ Poor ☐ Unacceptable
Please Explain____
____

3. Did the inspector display the knowledge and skills necessary to perform the inspection effectively? ☐ Yes ☐ No
Please explain ____
____

4. What problems, if any, were found with your irrigation system?
☐ Broken Sprinkler Heads ☐ Tilted Sprinkler Heads ☐ Low Sprinkler Heads
☐ Blocked Sprinkler Heads ☐ Clogged Sprinkler Heads ☐ Broken/ Leaking Pipes
☐ Broken/Leaking Valve ☐ Improper Pressure ☐ Overspray
☐ Incorrect Nozzle (spray distance and pattern) ☐ Unmatched Precipitation Rates
☐ Mixed Heads (Rotors & Spray on same zone) ☐ Poor Design (wrong head spacing)
☐ Inappropriate Sprinkler Head Type for Area ☐ Inefficient watering schedule
☐ Other: Please Explain______________________

5. Which of the above problems found with your irrigation system do you plan on fixing, if any? ____
____
____
____

6. What was most useful about the inspection? What did you learn?
____
____
____

7. What information would you have liked to receive that was not covered?__________
____
____
____

Additional Comments:

____
____
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____
____

May we contact you about the quality of your irrigation inspection?
□ Yes □ No
If you replied yes, please fill out the following information:

Name___________________________________ Phone #___________________________
Address____

Inspector:

Appendix C: Slow the Flow Impact Analysis Study

Executive Summary

Purpose of Report

This report is intended to summarize the impacts of the Slow the Flow Colorado Irrigation Inspection program on the outdoor (landscape) water use of program participants in the years 2004 and 2005. This report details the methodology and results of the analysis. Funding for the study was granted by the Colorado Water Conservation Board (CWCB).

Program History

Slow the Flow Colorado is a program that strives to reduce outdoor water waste by improving upon the efficiency of landscape irrigation systems and educating property owners on landscape best management practices. This is accomplished by providing irrigation system inspections (otherwise known as irrigation audits) at no charge to properties along the Front Range. Slow the Flow Colorado is closely modeled after a successful program developed by the Utah State University Cooperative Extension called Slow the Flow Save H20 and was adopted in 2004 in Boulder County, Colorado as a pilot program of the Center for ReSource Conservation (CRC). The clear demand for inspections during its pilot year prompted the CRC to implement Slow the Flow Colorado as a permanent program of the Western Water Conservancy (WWC), a division of the CRC. Each year, funding for the program has been procured from the participating cities and utilities as well as the Colorado Water Conservation Board.

Data

Several key pieces of data needed to be gathered, processed and analyzed in order to perform the analysis of Slow the Flow Colorado on reducing outdoor water use. These key data pieces included water consumption (gallons) and landscape size (sq. ft.) for each audited property, as well as annual evapotranspiration rates for Bluegrass (in.).

The analysis utilized water consumption data for households that received an irrigation inspection in either 2004 or 2005. The CRC was responsible for processing all of the water records obtained from the participating cities and was subsequently able to estimate the amount of water used outdoors. To determine the effects that Slow the Flow Colorado had on outdoor water usage, each household’s water usage before the inspection and after the inspection was analyzed. Equivalent amounts of data were needed for pre and post inspection analysis in order to make comparisons. In 2004 only one year of *pre-inspection* data was usable because 2002 (two years pre-inspection) was a major drought year in which significant mandatory watering restrictions were in effect. For the 2005 study group, only one year of *post-inspection* data was available. Therefore, for both study groups only one year of pre and post-inspection data was analyzed. Consideration of factors that might occur/change annually and affect watering behaviors (such as drought or watering restrictions) deemed that the 2004 participants be analyzed separately from the 2005 participants. All outliers and unusable data were removed from the two groups.

Method of Analysis

A pair of statisticians was hired to determine and carry out the statistical methods and tests that would be most appropriate and meaningful for the purpose of this analysis. Several key factors were taken into consideration when performing the analysis. The change in actual ET rates from year to year can vary by several inches. Therefore, if one year was extremely dry, households would be much more likely to use more water in that year as compared with a year that was wetter than normal. Without taking ET rates into account, changes in water usage could be incorrectly attributed to Slow the Flow Colorado instead of the simple change in ET requirements. Additionally, the statisticians pointed out that without comparing water usage to landscape size, water consumption data is not meaningful because large water users may be using the correct amount of water given their landscape size and water requirements.

Although performing an analysis that expresses the results in terms of gallons saved would be desirable, the results of such an analysis would not be statistically meaningful. A large variance in the number of gallons used by each household existed in the water records. The watering habits of households that were using extremely large amounts of water would overshadow any changes made by households using less amounts of water. Therefore, conveying results in terms of gallons saved would not be an effective way of analyzing the Slow the Flow Colorado Program. In order to conduct a statistically meaningful analysis of water consumption, data would need to be compared against a mean.

It was determined that percent above or below (noted as +/-) ET would be the most accurate and effective means of comparison. Percent +/- ET takes into account the ET rate for the year being analyzed as well as the amount of water used in relation to the household's landscape size. Moreover, since all of the data was expressed as a ratio, the problem of large water users overshadowing the rest of the group was considerably reduced.

The study groups were analyzed in several different configurations for the purposes of performing statistical tests. Each group was analyzed as a whole for the pre-inspection year and for the post-inspection year. Each group was also broken up into two sub-groups, which included households that watered above ET prior to the inspection and households that watered below ET prior to the inspection. This was done to observe whether these two groups behaved differently following the inspection since pre-inspection behaviors were initially very different.

The standard deviation was calculated for each of the abovementioned groups and was used to describe the distribution of the data and to form a test statistic (such as a t-test). A normality test was also performed for each of these groups to test whether or not the data was normally distributed. The results of the normality tests helped dictate which statistical methods were most appropriate for the analysis.

Results

Due to the different behaviors of the pre-inspection groups (households watering above or below ET) it was very difficult to quantify the differences between the means for the population as a whole. It was more informative to look at the pre-inspection groups separately.

When comparing the watering habits of properties that were watering above ET prior to the inspection with their watering habits after the inspection, a statistically significant reduction in water usage was observed. Results showed that in 2004 75% of participants that watered at rates above

ET prior to the inspection reduced their water usage after the inspection. In 2005, 79% of participants that watered at rates above ET prior to the inspection reduced their water usage after the inspection.

When comparing the watering habits of properties that were watering below ET prior to the inspection with their watering habits after the inspection, the trend was to use more water. However, these properties still tended to water either at or below the ET rates.

A non-statistical analysis of total outdoor gallons used by the various study groups in relation to gallons needed to replace ET showed that:

The 2004 group as a whole fell short of meeting the ET requirements by 2.6 million gallons in the pre-inspection year (2003). In 2005, this group fell short of replacing ET by a little more than 2.6 million gallons (a difference of approximately 56,000 gallons, or 2%.) It was observed that 2/3 of the 2004 group were watering below ET prior to the inspection.

The 2005 group as a whole watered beyond ET requirements by 5.8 million gallons in the pre-inspection year (2004). In 2006, this group still irrigated beyond ET requirements, but by 2.3 million gallons less. This is a 39% reduction in water use, and approximately 7 acre feet of water saved. It was observed that 2/3 of the 2005 group were watering above ET prior to the inspection.

As can be inferred by the above findings, Slow the Flow is an effective program when people are over-watering prior to the inspection.

The cost of conducting the number of inspections in the 2005 group (751) was approximately $57,000. Current estimates for the cost of infrastructure associated with the development of water range from $12,000 to $17,000 per acre foot (at a minimum). This would indicate that this conservation program is a cost effective method to meeting water supply needs.

Additional Considerations

The findings of this analysis can play an important role in helping water providers decide which properties to target for irrigation inspection programs such as Slow the Flow Colorado, as well as which alternative or additional water conservation measures, incentives or programs could be considered.

Based on the results of this analysis, the reduction of water use attributed to programs such as Slow the Flow Colorado will depend greatly on whether or not participants are over-watering prior to receiving an inspection. In order to know whether or not someone is over-watering and therefore receive an irrigation inspection, their water consumption data would have to be compared with their landscape size ahead of time. A common misconception is that if a property is using a large amount of water or has a large landscape, the property is most likely over-watering. However, a trend was observed during the course of this study that actually indicated the opposite. That is to say that the larger properties tended to be less likely to be over-watered. Nonetheless, it is very important to note that even if these large properties are watering the correct amount given their landscape size and the ET rate, they still might be categorized as a "high water user."

In the instances of high water users that have very large landscape sizes, the CRC would recommend that alternative initiatives such as limiting the amount of turf that can exist in new landscapes, reducing the amount of turf in existing landscapes, and implementing xeric alternatives to turf would be helpful in water conservation measures. Developing and enforcing landscape ordinances would also play an integral role in reaching water conservation goals.

Another finding observed during this analysis was the role that drought and mandatory watering restrictions had on outdoor water use. The 2002 drought prompted many cities along the Front Range to implement mandatory watering restrictions. As can be expected, during 2002 water use was considerably lower than average for most properties. However, a "roll-over affect" or "drought shadow" was observed in the year following the drought in which mandatory watering restrictions were no longer in effect. For example, in 2003, two-thirds of households analyzed were watering below the ET rate. However, in 2004, that number dropped to only one-third of households watering below the ET rate. In other words, a general trend was observed in which water use tended to increase with each year after the drought. The irrigation inspection program effectively reduced the water use of households watering above the ET rate in the years following the drought. Though the severe restrictions did result in reduced water use, the success of Slow the Flow Colorado provides the basis for efficiency as a means of water conservation, rather then solely relying on severe restrictions to meet water use reduction or conservation goals.

Another outcome to consider is that households watering below ET prior to the inspection tended to increase water use after the inspection (the trend was to water closer to actual ET rates, without watering above ET rates). Nonetheless, these customers still received valuable information from the inspection regarding Best Management Practices and efficient water use. The urban landscape has many environmental and community benefits, such as reducing the "heat island" effect and filtering storm water. Through Slow the Flow Colorado, customers can help maximize the benefits of the urban landscape by maintaining healthy lawns and using water as efficiently as possible.

Problems seen in residential irrigation systems occurred in both contractor and homeowner installed systems. In almost all cases maintenance problems contributed to inefficient water use and water waste. Improper design was also widely seen and posed a much larger burden on the homeowner to finance and complete changes that would improve upon efficiency. Landscape ordinances prior to installation could be an effective tool in addressing this problem. Another interesting finding was that even though organizations such as GreenCO, Associated Landscape Contractors of Colorado, Irrigation Association and Partners for a Clean Environment (PACE) exist, very few homeowners that participated in the Slow the Flow program were aware of any of these organizations and were not previously aware of the certification requirements/status of irrigation contractors in either their particular city or in Colorado. It was very clear that such organizations still have not penetrated the homeowner market sufficiently enough to be widely recognized by the general public, and not just industry professionals.

Appendix D: Sample Large Audit Report

Irrigation Inspection Report
Meadow Sweet Farm HOA
Erie, Colorado, 80516

Executive Summary

This report contains a summary and results of an irrigation inspection performed on Meadow Sweet Farm HOA on July 14, 2009. Nora Matell and Jenny Perich with the Center for ReSource Conservation (CRC) performed the inspection through the CRC's Slow the Flow Irrigation Inspection Program. The CRC is a non-profit organization that empowers our community to conserve natural resources. The Town of Erie has partnered with the CRC to offer this service to their customers in an effort to maximize irrigation efficiency and reduce water use.

Procedure

We performed the following steps as part of the inspection:

- Met with Judy Hunter (HOA Board Secretary) and Reuben from All Phase Landscaping
- Visually Inspected 22 Zones on the Property
- Performed Catch Cup Tests
- Performed Pressure Tests
- Performed Soil and Root Depth Tests
- Calculated a Customized Watering Schedule

Sprinkler Heads 101

There are two basic types of sprinkler heads: **spray heads** and **rotor heads**. Spray heads water in a fixed spray pattern when the system is turned on. Rotor heads water in a rotating pattern and tend to be used to cover larger areas.

Test Results and Findings

We found the sprinkler system at Meadow Sweet Farm to be in good condition. In general, heads and nozzles were in good condition and overspray was minimal. We did note a few broken heads that should be replaced as soon as possible.

We tested the distribution uniformity (DU), operating pressure, soil type and root depth in eight areas. We found an average DU of 50%, and a range of 42-56% for all zones tested. We recommend correcting the system so that all zones perform with a DU value of at least 70%.

We found an average pressure of 30 PSI on spray zones and 25 PSI on rotor zones. The design pressure for spray heads ranges from 20 to 30 PSI; for rotor heads it ranges from 25 to 80 PSI. Your pressure was within the design range.

We found that most of your soil is sandy clay, and that your average root depth is 4.5 inches.

Distribution Uniformity

Distribution Uniformity (DU) is a measure of how evenly a sprinkler system waters a given area. It is measure as a percentage.

DU impacts the appearance of an area and how much water it needs. For example, if an area has a distribution uniformity of 50%, some parts of it get half as much water as the area as a whole. If the watering schedule is set to give an appropriate amount of water to the whole area, these parts will look poor. If the watering schedule is set to give an appropriate amount of water to the areas receiving the least water, it will give the area as a whole twice as much water as it needs. We recommend a minimum distribution uniformity of 70% for all zones.

During the visual inspection and testing, we found the following problems on the sprinkler system:

- Several broken heads
- Mixed heads within zones (model, brand, and type)
- Sunken and tilted heads
- Clogged and broken nozzles
- Overspray
- Poor head spacing

Based on the test results and our findings, we recommend that Meadow Sweet Farm take the following steps.

- Replace broken heads and nozzles (this is easy to do and will be a significant improvement)
- Tune up system, fixing sunken and tilted heads, clogged nozzles, and overspray (fairly simple)
- Evaluate head types on mixed zones along 119th Street (more complex)

Watering Schedule
In the body of the report, we have provided watering schedules for zones on which we performed catch cup tests. We base our watering schedules off of evapotranspiration (ET), the amount of water grass and the soil loses to evaporation and transpiration each year. We use a historical average ET of 27 inches per watering season to determine our schedules.

In general, we found that the current watering schedule was either somewhat less or similar to our recommendations for spray zones, and significantly longer than our recommendations for rotor zones. You are already watering all zones with two cycles per watering; we recommend increasing the number of cycles to three per watering for the zones along 119th Street.

Different Watering Times for Spray and Rotor Zones

Spray and rotor heads emit water at different rates, and usually need to be programmed to water for different amounts of time. Spray heads usually need to be watered for approximately 60% of the length of time of rotor zones.

Conclusion
Thank you for your participation in Slow the Flow Colorado. We hope that the data and recommendations in this report will help you maintain a beautiful landscape while using water as efficiently as possible. If you have any questions, please feel free to contact our Program Manager at 303-999-3820 x 210.

Nora Matell and Jenny Perich
Slow the Flow Colorado
Center for ReSource Conservation

Full Report

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Inspection Procedure

Upon arrival at Meadow Sweet Farm we met briefly with Judy Hunter, the HOA board secretary, as well as with Reuben from All Phase Landscaping. After this meeting, we performed the following steps of an inspection:

- Visual Inspection. We inspected all sprinkler heads within all 22 sprinkler and drip zones on the property. During the visual inspection, we observed the zones as they operated, looking for and recording any problems found.
- Catch Cup Tests. We chose eight areas on the property to perform catch cup tests. For each test, we laid out a set of catch-cups in a grid pattern on the turf and recorded the amount of water that fell in each cup during a specified period of time. This gave us a measure of how evenly the sprinkler system waters in each area, called *distribution uniformity*, and a measure of how quickly the system waters, called *precipitation rate*.
- Pressure Tests. We measured the operating pressure of the sprinkler system in each area where we performed a catch cup tests. We compared the observed pressure to the recommended operating pressure for each head type.
- Soil and Root Depth Tests. We took a soil sample in each test zone to determine soil type and root depth.
- Determine a Customized Watering Schedule. We used the precipitation rate and the soil type of each tested zone to determine a customized watering schedule for that zone. These watering schedules are included with this report.
- Written Report. After leaving the site, we wrote this report of our results.

Site Description

Meadow Sweet Farm is an HOA property consisting of approximately 40,000 square feet of turf, native grass, and shrubs along Erie Parkway and 119th Street. Twelve spray and rotor zones irrigate the turf, and 10 drip zones irrigate the shrubs; the native grasses are not irrigated. The irrigation system is controlled by two control clocks. Control Clock 1, located at the corner of Erie Parkway and Harvest Pointe Drive, is a Rainbird ESP-LX Modular that operates three rotor zones, one spray zone, and four drip zones near the intersections of Erie Parkway and Harvest Pointe Drive and Erie Parkway and 119th Street. Control Clock 2 is located at the corner of Harvest Pointe Drive and 119th Street and operates eight rotor and spray zones and six drip zones along 119th Street. Turf zones are typically irrigated 3-4 days per week, with two cycles of 10-30 minutes per irrigation day. Drip zones are typically irrigated three days a week for 45 minutes per irrigation day.

Findings

Issues Needing Immediate Attention
Broken heads were found in Zone 3 of Control Clock 2 (south end of the zone by street) and in Zone 7 of Control Clock 2 (front of bushes past end of drainage ditch and at the end of drainage ditch). A leak in the drip line was observed in Zone 5 of Control Clock 1.

General Findings

	Distribution Uniformity (%)	Precipitation Rate (in./hour)	Root Depth (inches)
Average	50	0.7	4.5
Range	42-56	0.5-1.3	3-5

We recommend that the irrigation system be tuned up and corrected to perform at a minimum 70% distribution uniformity for all zones.

We found grass root depths of 3-5 inches, which is slightly lower than our recommended 6 to 12 inch range. We encourage deep roots as they help grass resist disease and drought.

We found soil types of loam and sandy clay. We used the soil type and precipitation rate found for each zone to determine a customized watering schedule for that zone.

	Rotor Pressure	Spray Pressure
Average	25	30
Range	20-30	26-35

Depending on the brand and model, the design pressure for rotor heads ranges from roughly 25 to 80 PSI. The design pressure for spray heads ranges from 20 to 30 PSI.

We were pleased to see pressures throughout the system within the suggested pressure range. This should help you conserve water by reducing evaporation. In general, we found the zones along Erie Parkway to be well maintained, with only a few minor adjustments needed. We were also pleased to see that you are already implementing cycling in your watering schedule so that watering times are broken up to allow the water time to soak into the soil. Cycling can significantly reduce the amount of water that pools on the surface and/or runs off before it is able to infiltrate the ground. It was also nice to see that you have made an effort to reduce the amount of irrigated area by including non-watered native grasses in your landscaping. This certainly saves you water and money versus an equivalent amount of turf.

Problems Found:

Misaligned, Clogged, Blocked, Sunken and Tilted Heads

Some of the heads were misaligned, clogged, blocked, sunken and/or tilted. Over time heads tend to sink and tilt due to the natural settling of the earth, as well as wear and tear from foot traffic and lawn maintenance. These heads, though still operational, are either not spraying water onto the turf or are spraying in an undesirable pattern. These seemingly minor issues have the potential to greatly reduce the efficiency of the system. In many cases, it results in a huge alteration of the spray pattern for that sprinkler head and can result in brown spots, misting, and wasted water. These problems are relatively inexpensive and easy to fix and once they are addressed, can increase the system's efficiency dramatically. Raise and level all heads to the ground surface and unclog or unblock affected heads. At the time that the grass is at its tallest, the spray from the heads should not be deflected or blocked.

Unmatched Precipitation Rates

All of the heads within a single zone should have matched precipitation rates. For example, a rotor head with an arc of 360 degrees should emit 2x as much water in the same amount of time as a rotor head with an arc of 180 degrees. This is because the head with a 360 degree arc has to cover twice as much area. When precipitation rates within a zone are not matched, uniform delivery of water is difficult to achieve. This will cause overly wet and/or overly dry spots in the landscape. Check all heads to make sure matched precipitation rates are being achieved.

Mixed Zones

Design specifications (radius and pattern of throw, operating pressure, and precipitation rates) for sprinkler heads are specific to the brand, type and model. Therefore, different brands and models of heads should not be placed on the same zone as one another because it will create inefficient watering.

Some zones had both fixed spray heads as well as rotor heads located on the same zone. Fixed spray heads are designed to emit an average of 50% more water than rotor heads. Since watering times can only be controlled zone by zone and not by individual heads, the areas watered by sprays will receive an average of 50% more water than the areas watered by rotors. Moreover, the optimal operating pressure level for sprays versus rotors are very different. Fixed spray heads are designed to operate best between 20 and 30 PSI, while rotors are designed to operate best between 40 and 80+ PSI. Therefore, if the time and pressure is correct for one type of head, it will inherently be wrong for the other type of head. For the above reasons, sprays and rotors should never be located on the same zone. A direct result of this type of design is turf that has spots of overly wet and/or overly dry areas. Make all heads within a zone as uniform as possible. If a head needs to be replaced, try to replace it with the same head type that is on the rest of the zone.

In your specific case, most spray heads located in rotor zones were equipped with rotary nozzles. These nozzles are designed to permit spray heads and rotor heads to be mixed within a zone. However, precipitation rates still need to be matched (see "Unmatched Precipitation Rates" above).

Poor Head Spacing

A few of the zones had heads that were spaced too far apart to be able to get adequate head to head coverage, thus creating brown spots. Head to head coverage is when the spray from one head reaches the heads next to it and visa versa. Head spacing and or throw radius should be adjusted to achieve head to head coverage. We also noted a few heads that were placed several feet to one side of a corner, rotating to spray the corner, and thus creating significant overspray. In these cases, we recommend moving the head to the corner to reduce overspray.

Overspray
Some of the heads on the property were over-spraying onto sidewalks and other hardscapes. To avoid overspray, heads should be placed several inches away from the edge of the landscape. To reduce the throw radius of a sprinkler head up to 20%, the radius adjustment screw should be utilized. If the radius needs to be reduced more than 20%, a nozzle with a shorter throw radius should be installed. Many of your heads had radius adjustment screws that had been tightened more than 20%; we recommend replacing these nozzles to achieve the desired radius.

Incorrect Spray Patterns
Some of the heads had incorrect arcs. The arc of the sprinkler head is the degree of a circle the head sprays water. When the arc is too wide it can lead to overspray onto undesired areas. Conversely, when the arc is too narrow it can lead to dry spots and poor coverage. With a few minor adjustments to the sprinkler heads, this problem can be easily remedied. For hard to cover areas that are watered with spray heads, we recommend using a Variable Arc Nozzle (VAN) that allows a custom arc to be set. In a few cases, you were used specialized Side Strip Nozzles to spray areas that would have been better covered by a traditional 180° arc nozzle.

Check Valves
After the system was turned off, water continued to run out of lower elevated heads. This was because the water left in the system was draining. It is possible to prevent this by installing heads that have check valves which keep water in the sprinkler pipes after the system has been shut off. Not only will this eliminate the loss of water from the system, but it will also prevent excess wear and tear on the system's pipes. Check valves can typically be retrofitted onto most head types. Some of the heads in your system had check valves, but not all.

Visual Inspection Notes

Control Clock 1: Corner of Erie Parkway & Harvest Pointe Drive			
Zone Number	*Type: (**S**pray, **R**otor, or **D**rip)*	*Brand and Model*	*Inspection Notes*
1	Rotor	Hunter PGP	Poor head spacing
2	Rotor	Hunter PGP Rainbird 5000+	Sunken heads, inappropriate nozzles (too large, screw screwed in a lot to reduce radius to appropriate level), overspray, poor head spacing (move NW corner head to corner to reduce overspray significantly)
3	Drip		
4	Drip		
5	Drip	Microsprayers	Leak in line near Meadow Street sign (corner of Erie Pkwy & Harvest Pointe Dr)
6	Spray	Rainbird 1800	Broken nozzle (SW corner of zone), sunken head
7	Drip		
8	Rotor	Rainbird 3500	Overspray

Control Clock 2: Corner of Harvest Pointe Drive & 119th Street			
Zone Number	*Type: (**S**pray, **R**otor, or **D**rip)*	*Brand and Model*	*Inspection Notes*
1	Rotor / Spray with rotor nozzles	Rainbird 3500 Hunter PGM & PGJ Rainbird 1800 with Rainbird Rotary Nozzles	Mixed heads, sunken heads, blocked heads, overspray (radius and arc)
2	Rotor / Spray with rotor nozzles	Rainbird 3500 & 4500 Hunter PGJ Rainbird 1800 with Rainbird Rotary Nozzles	Mixed heads, sunken heads, blocked heads, overspray (radius and arc), tilted heads
3	Rotor / Spray with rotor nozzles	Rainbird 3500 Hunter PGJ Rainbird 1800 with Rainbird Rotary Nozzles	Mixed heads, sunken heads, blocked heads, broken head (southeast corner of zone)
4	Rotor / Spray with rotor nozzles	Rainbird 3500 Hunter PGJ & I-20 Rainbird 1800 with Rainbird Rotary Nozzles	Mixed heads, overspray (arc), tilted heads
5	Rotor / Spray with rotor nozzles	Hunter PGM Rainbird 1800 with Rainbird Rotary Nozzles	Mixed heads, overspray (arc)
6	Rotor	Hunter PGP Rainbird 5000+	Overspray (arc), blocked heads
7	Spray / Rotor	Rainbird 1800 Hunter PGM	Mixed heads, sunken heads, overspray, poor head spacing, tilted heads, heads facing wrong way or arc radius adjusted poorly, inappropriate nozzles (side strip nozzles in use in some places), broken nozzle, clogged nozzles, broken heads (front of bushes past end of drainage ditch, end of drainage ditch)
8	Spray / Spray with rotor nozzles	Rainbird 1800, some with Rainbird Rotary Nozzles	Sunken heads, tilted heads, clogged nozzles, poor head spacing
9	Zone does not exist		
10	Drip		
11	Drip		
12	Drip		
13	Drip		
14	Drip		
15	Drip		

Test Results

	Area 1: rotor zone	**Area 2: rotor zone**
Clock ID	1	1
Zone Numbers	1	2
Root Depth (inches)	3	5
Soil Type	Loam	Loam

Head Brand	Hunter	Hunter / Rainbird
Head Model	PGP	PGP / 5000+
Head Pressure (PSI)	30	20
PR (inches/hr)	0.6	0.5
DU (%)	51	53
Current Minutes/Week	180	180
Rec. Minutes/Week	100	120

	Area 3: spray zone	**Area 4: rotor zone**
Clock ID	1	1
Zone Numbers	6	8
Root Depth (inches)	5	5
Soil Type	Loam	Loam
Head Brand	Rainbird	Rainbird
Head Model	1800	3500
Head Pressure (PSI)	35	30
PR (inches/hr)	1.3	0.65
DU (%)	56	46
Current Minutes/Week	48	180
Rec. Minutes/Week	48	92

	Area 5: rotor/spray zone	**Area 6: rotor/spray zone**
Clock ID	2	2
Zone Numbers	1	1
Root Depth (inches)	4	3+
Soil Type	Sandy clay	Sandy clay
Head Brand	Rainbird / Hunter	Rainbird / Hunter
Head Model	3500, 1800 w/rotary nozzles / PGM, PGJ	3500, 4500, 1800 w/rotary nozzles / PGJ

Head Pressure (PSI)	26	20
PR (inches/hr)	0.6	0.7
DU (%)	56	42
Current Minutes/Week	200	200
Rec. Minutes/Week	102	90

	Area 7: rotor/spray zone	Area 8: spray zone
Clock ID	2	2
Zone Numbers	4	8
Root Depth (inches)	4+	3+
Soil Type	Sandy clay	Sandy clay
Head Brand	Rainbird / Hunter	Rainbird
Head Model	3500, 1800 w/rotary nozzles / PGJ, I-20	1800, some w/rotary nozzles
Head Pressure (PSI)	22	26
PR (inches/hr)	0.6	0.6
DU (%)	50	50
Current Minutes/Week	200	80
Rec. Minutes/Week	102	102

Watering Schedules

We base our watering schedule off of Evapotranspiration (ET). ET is the amount of water that plants and the soil lose to evaporation and transpiration each year, and is the amount of water that a plant needs to survive. We base our recommended schedule off of an average historical ET rate for bluegrass of **27 inches per year** in the Denver area. We recommend irrigating to replace this lost amount of water. While 27 inches per year is a historical average, if the weather is significantly hotter and drier or cooler and wetter than average, you may need to adjust your watering schedule.

Cycle and Soak

Watering in short cycles, or 'cycling' is important in heavy clay soils, on slopes, or when sprinklers have a high precipitation rate. For most systems, we suggest breaking up watering times into two or three cycles, separated by roughly an hour to give time for the water to soak. This will help prevent runoff, and give your turf a deeper and healthier watering. On most control clocks, the 'multiple start times' feature can be used to implement cycle and soak irrigation.

Recommended Watering Schedule
We recommend this watering schedule as a GUIDE during non-restrictive years. We have provided a schedule for zones on which we performed catch cup tests. Zones that have similar precipitation rates (usually one with the same head types and similar designs) can use the recommend schedule as a base starting point. We recommend adjusting this schedule for varying microclimates, such as sun exposure, in different zones.

We do not recommend drastically changing watering times in a short period of time; this will stress the turf significantly. If recommended watering schedules are significantly different than the current watering schedule, we recommend slowly reducing watering times to ease the turf into the new watering schedule.

Recommended Schedules:

Clock: 1		Zone: 1		Zone Type: rotor	
Current minutes/week: 180		Recommended minutes/week: 100			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	2	25	50	75
June-August	2	2	25	50	100
September	1	2	25	50	50

Clock: 1		Zone: 2		Zone Type: rotor	
Current minutes/week: 180		Recommended minutes/week: 120			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	2	30	60	90
June-August	2	2	30	60	120
September	1	2	30	60	60

Clock: 1		Zone: 6		Zone Type: spray	
Current minutes/week: 48		Recommended minutes/week: 48			
Month	Watering Times	Cycles	Minutes Per	Total Minutes	Total Minutes

	Per Week		Cycle	Per Watering	Per Week
May	1.5	2	12	24	36
June-August	2	2	12	24	48
September	1	2	12	24	25

Clock: 1		Zone: 8		Zone Type: rotor	
Current minutes/week: 180		Recommended minutes/week: 92			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	2	23	46	69
June-August	2	2	23	46	92
September	1	2	23	46	46

Clock: 2		Zone: 1		Zone Type: rotor / spray	
Current minutes/week: 200		Recommended minutes/week: 102			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	3	17	51	76
June-August	2	3	17	51	102
September	1	3	17	51	51

Clock: 2		Zone: 2		Zone Type: rotor / spray	
Current minutes/week: 200		Recommended minutes/week: 90			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	3	15	45	67
June-August	2	3	15	45	90
September	1	3	15	45	45

Clock: 2	Zone: 4	Zone Type: rotor / spray
Current minutes/week: 200	Recommended minutes/week: 102	

Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	3	17	51	76
June-August	2	3	17	51	102
September	1	3	17	51	51

Clock: 2		Zone: 8		Zone Type: spray	
Current minutes/week: 80		Recommended minutes/week: 102			
Month	Watering Times Per Week	Cycles	Minutes Per Cycle	Total Minutes Per Watering	Total Minutes Per Week
May	1.5	3	17	51	76
June-August	2	3	17	51	102
September	1	3	17	51	51